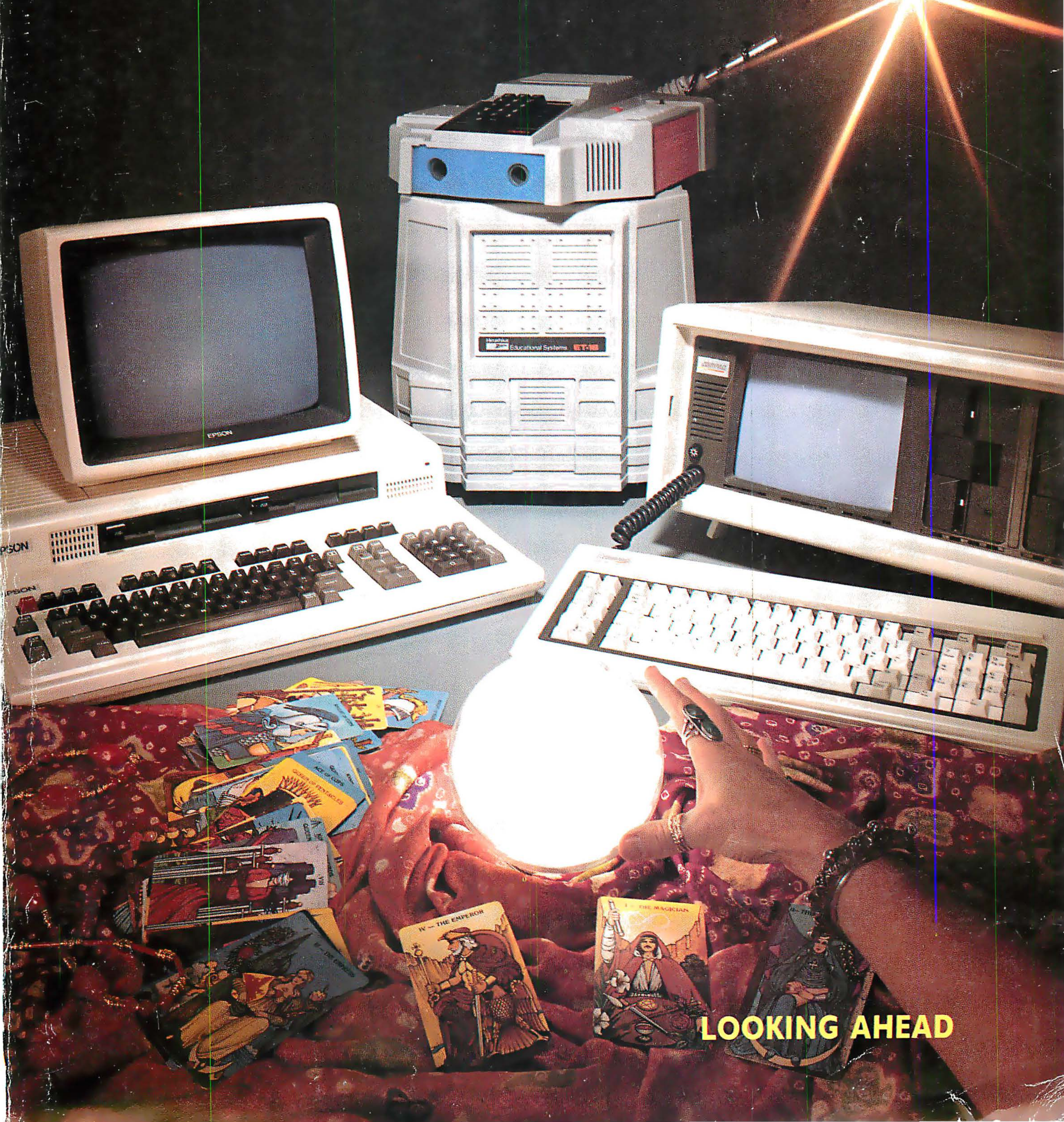
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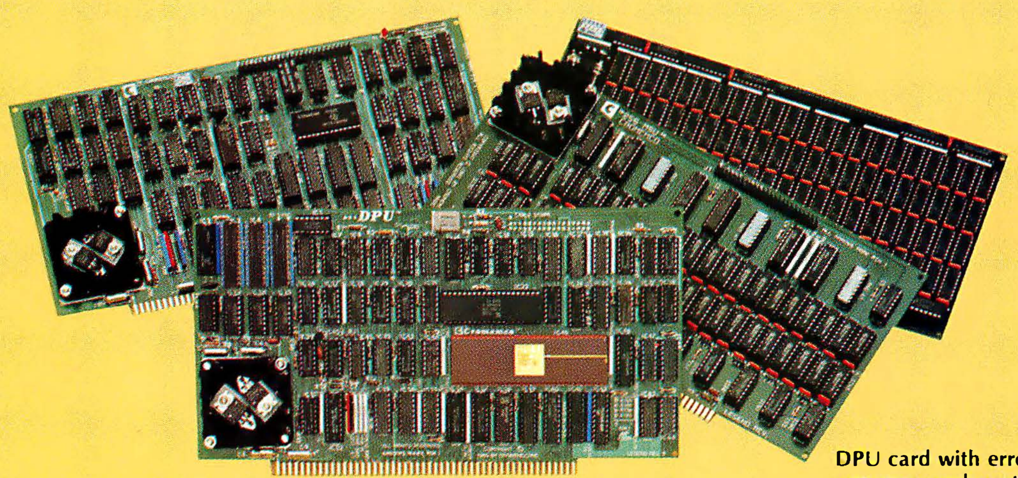
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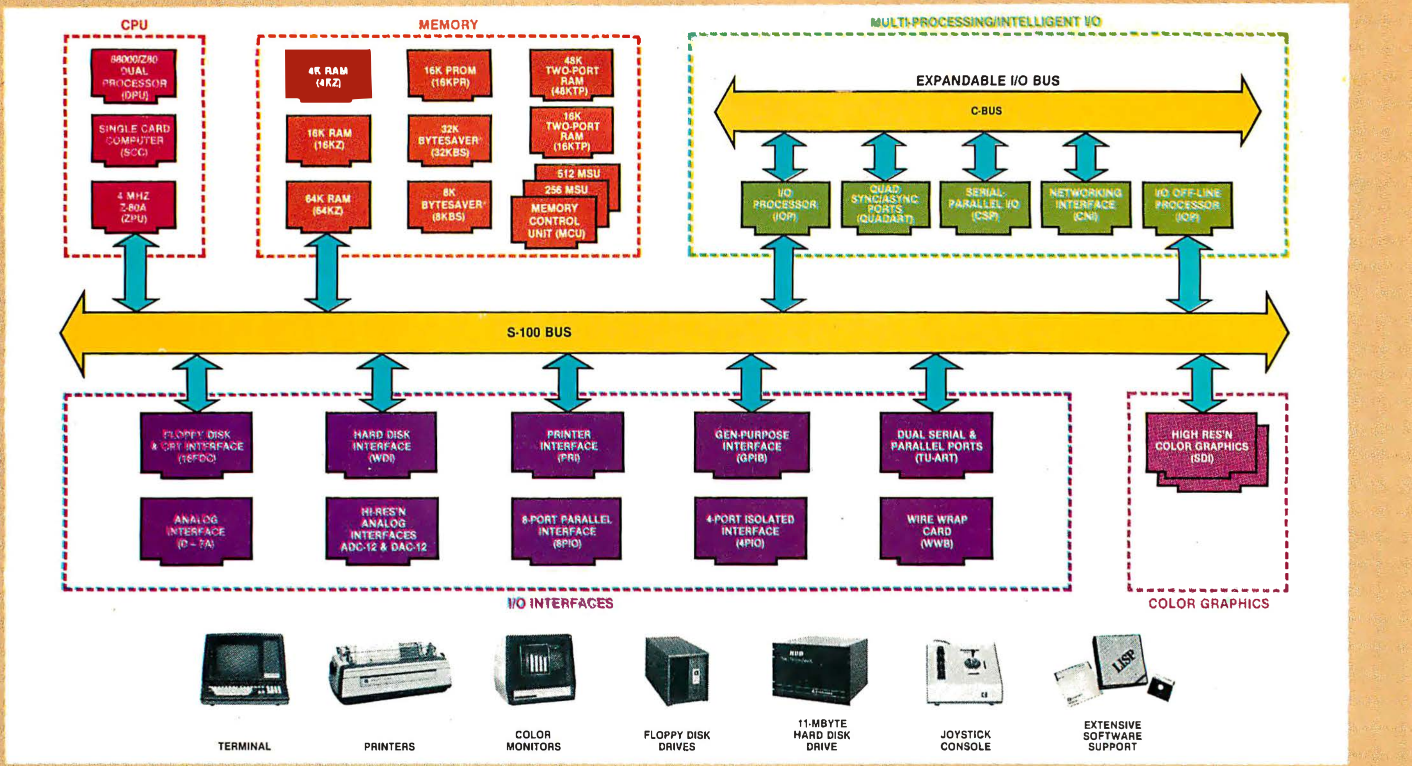
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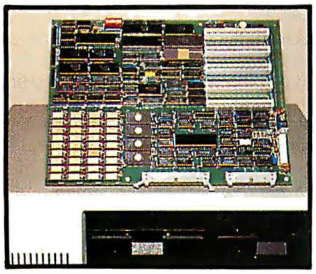
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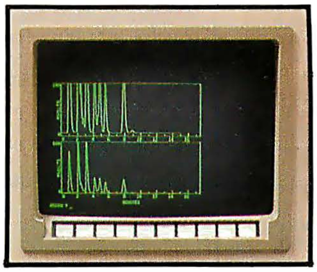
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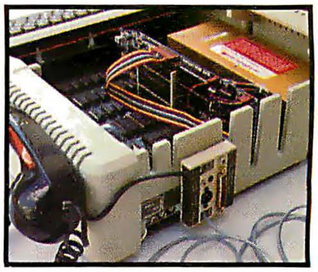
Nucleus



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In This Issue

The microcomputer industry is still moving along at a good clip. New and improved products proliferate and the battle for shelf space and consumers' cash is as heated as ever. This month we feature several of the latest offerings and look ahead at the shape of things to come. Showcased in our cover photo, by Paul Avis, are three such items: the Compaq computer, a portable unit that boasts complete compatibility with the IBM Personal Computer; the HERO-1 Robot from Heath Co., an educational device that demonstrates principles of automation and robotics; and the Epson QX-10/Valdocs System, a machine noteworthy for the way in which its software and hardware are integrated (for a product description see September 1982 BYTE, page 54). Chris Morgan describes "IBM's 'Secret' Computer: the 9000," Billy Garrett reviews "The Timex/Sinclair 1000," Timothy Stryker discusses "The Next Generation of Microprocessor," and Greggory S. Blundell looks at "Personal Computers in the Eighties." Gregg Williams reports on his recent trip to the Personal Computer World Show in London in "Microcomputing, British Style." Philip A. Schrodt gives us a first-person report of the U.S. Festival, a high-tech rock concert, in "Meet You at the Fair." Steve Ciarcia concludes his three-part article "Build the Circuit Cellar MPX-16 Computer System." Plus we have our regular features and reviews.

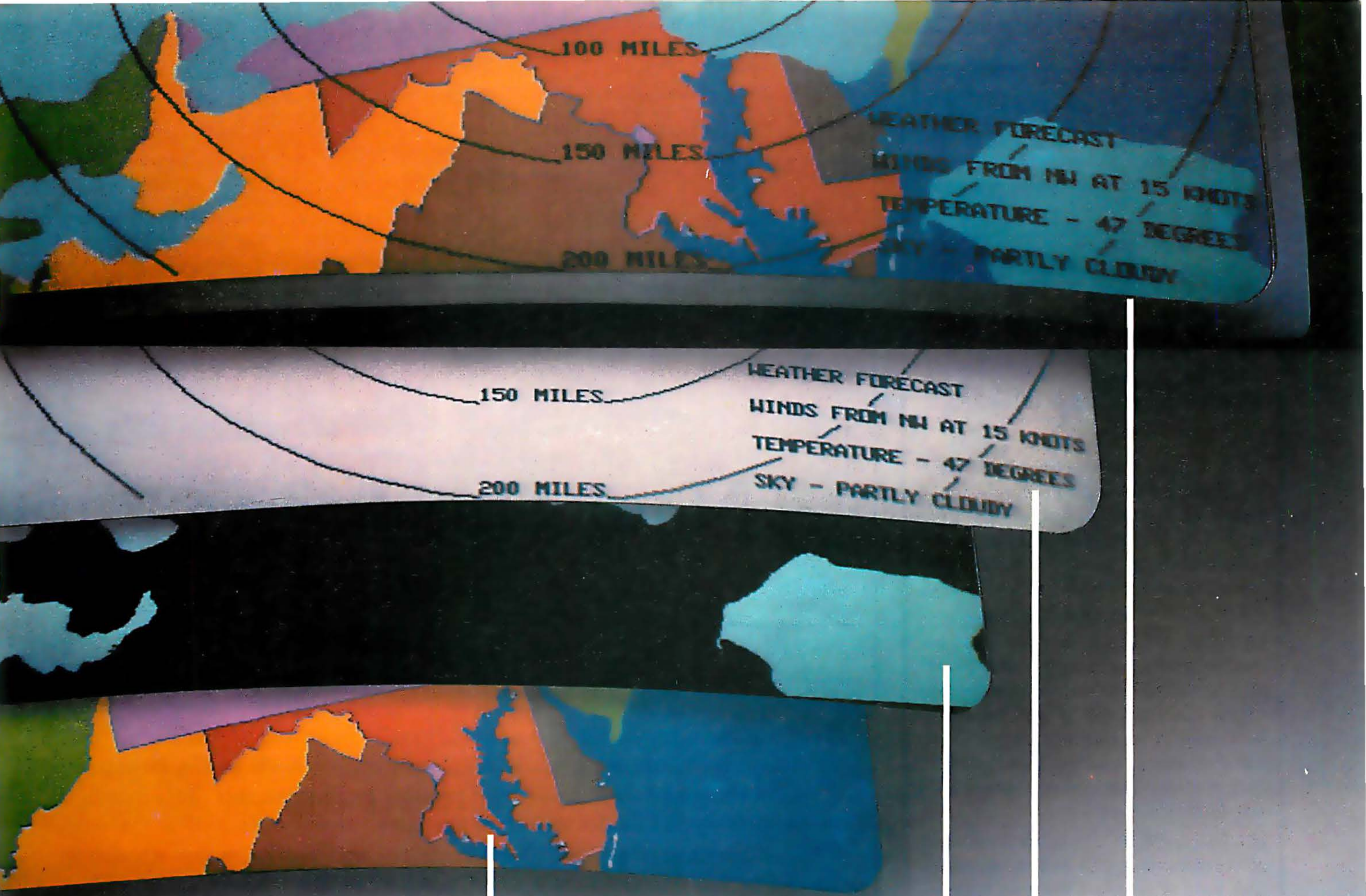
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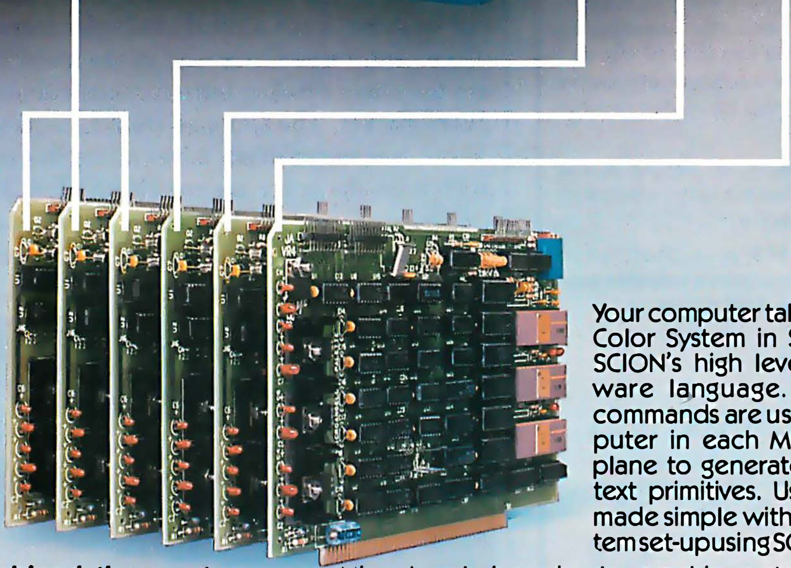
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Editorial

New Hardware

by Chris Morgan, Editor in Chief

The January issue of BYTE has traditionally been our showcase for new microcomputer hardware because it follows on the heels of the November COMDEX show and the scores of fall product announcements. This month is no exception—you'll find a wealth of the latest items herein.

The industry's new product fever rages on, spurred by record growth in sales and profits. Apple, Tandy, and Commodore, the three biggest names in our business, posted fiscal 1982 sales increases of 75 percent, 70 percent, and 63 percent, respectively—all in the midst of a recession. Equally encouraging are the many product introductions coming from companies new to the computer market. The Compaq from Compaq Computer Corporation, Houston, Texas, is featured in our cover photo this month (for story see page 30). Along with it on the cover are the Heath HERO-1 microcomputer-controlled robot (see page 86) and the Epson QX-10/Valdocs System, which was described by Senior Editor Gregg Williams in the September 1982 BYTE (page 54).



Photo 1: *The Compaq, a portable IBM look-alike from Compaq Computer Corp.*


PERCOM DATA

Editorial

The Compaq

Take the IBM Personal Computer and the Osborne 1, put them in an inertia bonding machine, flip the switch, and you have the Compaq computer. At least, that was my first impression when I saw the machine this past summer.

The Compaq was designed to be totally compatible with the IBM Personal Computer. It accepts all the peripheral boards for the IBM, and it was able to run every piece of IBM software we tried in it. It costs less than a comparably equipped IBM Personal Computer ($2995 for the 128K-byte system with one double-density drive, versus $3735 for a similarly equipped IBM PC). And at 28 pounds, the Compaq is definitely transportable. Combining the monochrome and color graphics boards onto one board is another good idea used in the Compaq. The machine's designers deserve straight As for their efforts.

The Compaq will undoubtedly give IBM much to think about. In fact, a spate of IBM look-alikes will soon descend on the marketplace, most likely forcing IBM to restructure its pricing schedules.

Epson's QX-10

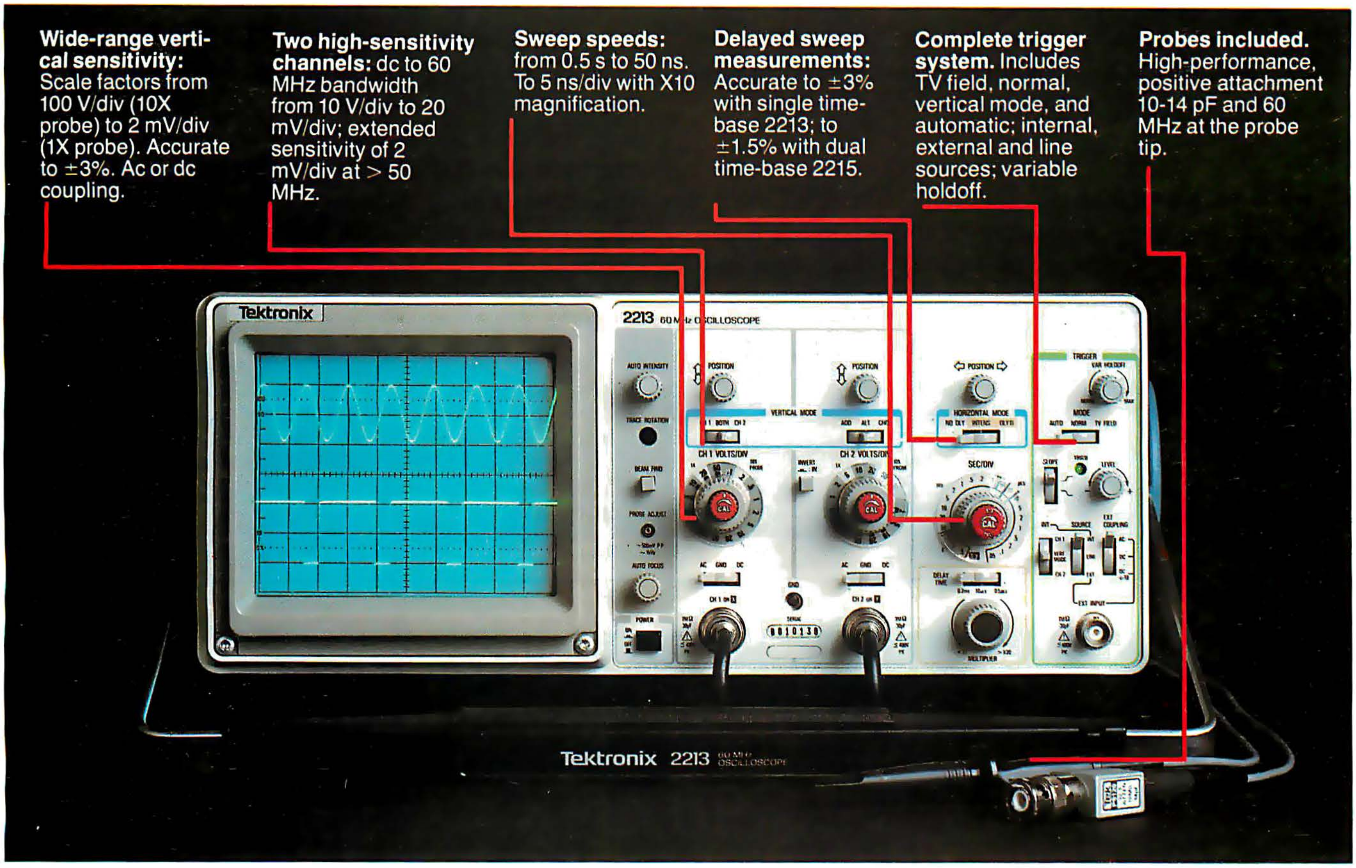
First described by Gregg Williams in his September article, the QX-10 is, at first glance, not a revolutionary machine. Yet in many subtle ways it is. On the surface, its specs are not spectacular: 8 bits, CP/M, two 5¼-inch floppy-disk drives, and a monochrome monitor. But the real power of the machine lies in its careful integration of software and hardware. The software was designed with the hardware in mind and vice versa.

To use an overly familiar phrase, the QX-10 is user-friendly. For example, the Valdocs (for "valuable documents") software system lets you work with characters, numbers, graphics, and time (in the form of an electronic



Photo 2: *The Epson QX-10/Valdocs System.*

Tek's most successful scope series ever: At $1200-$1450, it's easy to see why!



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datebook and event scheduler). The keyboard, patterned after Epson's proposed keyboard standard (see "An Introduction to the Human Applications Standard Computer Interface" by Chris Rutkowski, Part 1, October 1982 BYTE, page 291 and Part 2, November 1982 BYTE, page 379) allows even naive users to work with the Valdocs system quickly and easily.

Such products reflect a growing concern for the user, a recognition that the old standards for hardware and software performance are no longer good enough. We need better-quality products, more attention to details, better-written manuals, and state-of-the-art features. Fortunately, the industry is listening.

Commodore 64 Guide

We just saw the *Commodore 64 Programmer's Reference Guide* (published by Commodore Business Machines Inc. and Howard W. Sams and Co. Inc.). The book explains the workings of the Commodore 64, a machine we didn't fully appreciate until now. The Commodore 64 gives you a lot for its $599 suggested list price: 64K bytes of RAM, another 28K bytes of ROM (most of the top 32K bytes of memory can switch among various combinations of RAM and ROM), two text modes (monochrome and four-colored text), two high-resolution modes (320 by 200 pixels in monochrome and 160 by 200 in four-color mode), eight *sprites* (easily movable, colored, user-defined shapes), and a sophisticated three-voice sound synthesizer. In addition, you can mix graphics and text modes, display up to 24 rows of 64 characters each, and do smooth scrolling of video images (as on the Atari 400 and 800 computers). The machine is far from perfect, but it is, in its own way, as sophisticated as the state-of-the-art Atari machines. Look for a review of the Commodore 64 in an upcoming issue of BYTE. ■

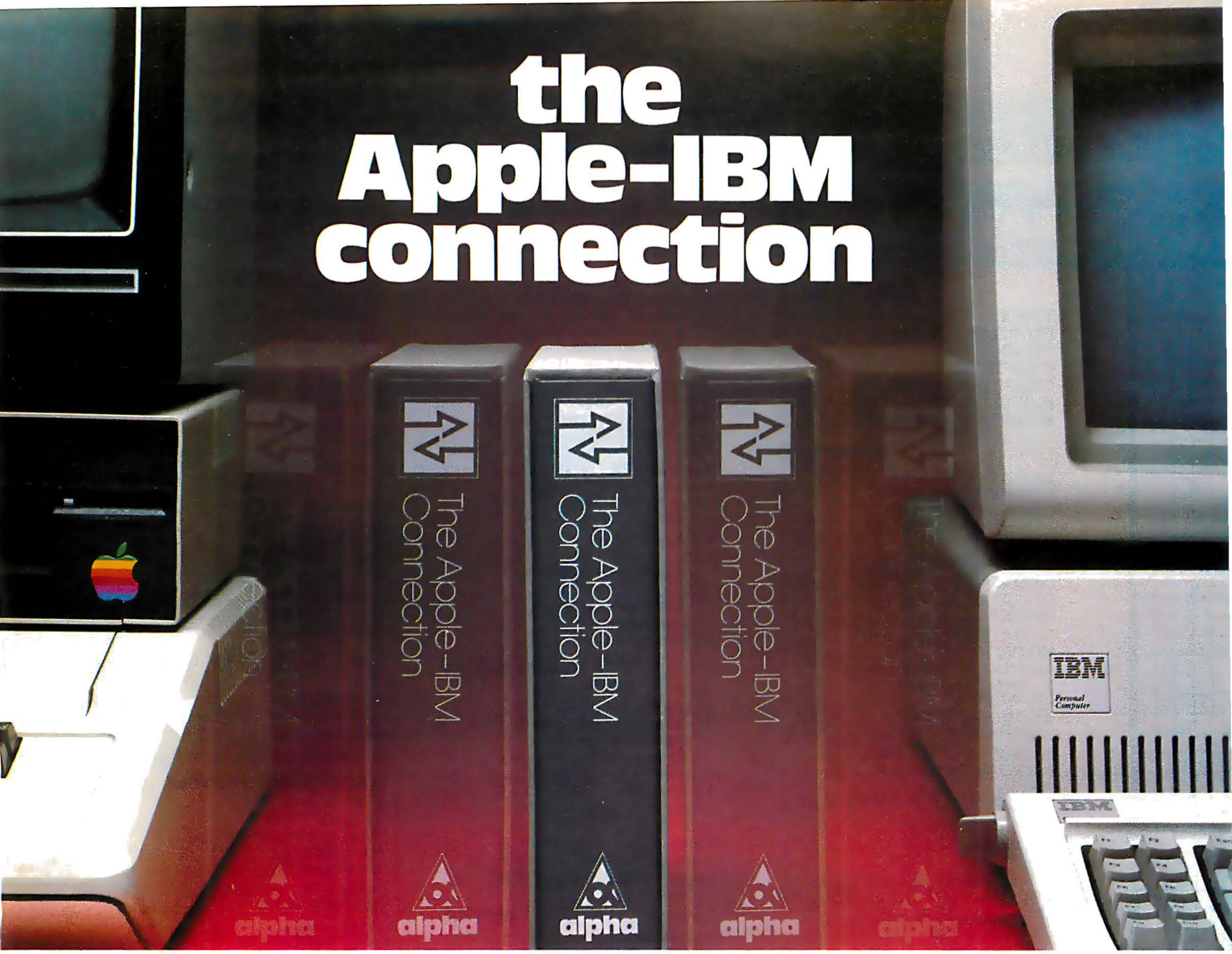
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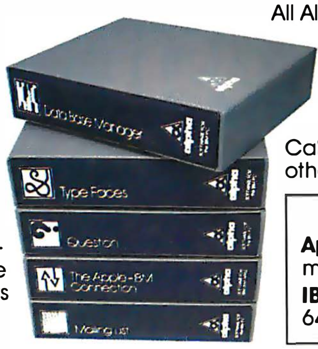
Designed for the non-technical user, the Apple-IBM Connection comes with a disk for the Apple and a disk for the IBM. Connect the two computers with a cable or a telephone modem and insert the disks.

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Letters

Oscilloscope Program Extended

Larry Korba's article "Turn Your Apple II into a Storage Oscilloscope" has many applications besides the one discussed. (See the September 1982 BYTE, page 520.) Looked at from a more general viewpoint, his program will log analog data at regularly spaced intervals. The display portion may or may not be important to a particular data-logging operation, but data-logging techniques have many applications.

The purpose of this letter is to remove one of the limitations of the program. In his program, the time between samples is limited to a maximum of 50 milliseconds (ms) corresponding to a sweep time of 1000 ms/division. The sample interval can easily be extended to periods as long as two hours, allowing data to be logged over a period of days or weeks.

The following modifications are required. The T1 timer on the 6522 register is set up to run in its free-running mode, toggling pin PB7. The T2 timer/counter is set up to count pulses. Both of these modifications are accomplished by loading the ACR with 0E0 hexadecimal on lines 174 and 175 of Korba's listing 1b. Next, pin PB7 is connected to pin PB6. Now, T2 is counting pulses from T1. The time T between interrupts from T2 is:

$$T = 2(N1 + 2)(N2 + 1)T_C$$

where $N1$ is the 16-bit number in the T1 timer and $N2$ is the 16-bit number in the T2 timer. (For further information, see Marvin L. De Jong, *Apple II Assembly Language*. Indianapolis, IN: Howard W. Sams & Co., 1982.) T_C is the clock frequency and is approximately 0.97779 microseconds, not 1 microsecond. Of course, the IER should be loaded with 0A0 hexadecimal rather than 0C0 hexadecimal (lines 180 and 181 in listing 1b), and another ASL A instruction should follow the ASL A instruction on line 76 of listing 1b.

A short sequence of BASIC instructions will convert the desired time T between samples into $N1$ and $N2$, which you can then POKE into the appropriate 6522 registers. It is probably useful to start with $N = 0$ for short sample intervals and increase $N2$ as necessary to achieve the desired sample interval.

For example, with $N1 = 60898$ and $N2 = 60455$ a sampling interval of two hours is obtained. You could collect data over a period of 20 days at this rate.

Again, the modifications are simple and the versatility of the program is increased if, in effect, the timers on the 6522 are combined to provide a 32-bit timer rather than a 16-bit timer.

Marvin L. De Jong, Professor
Department of Mathematics-Physics
The School of the Ozarks
Point Lookout, MO 65726

No Shortage of Multiuser Unix Systems

In the BYTELINES section of the August 1982 BYTE, a brief editorial was presented concerning the apparent shortage of actual shipments of Unix-based multiuser microcomputer systems. (See "Unix Where Art Thou," page 448.)

Codata Systems Corporation has been shipping Unix-based multiuser systems for more than a year. These systems operate under Unisis, our variant of Unix version 7, and provide users with all of the benefits of this powerful operating system.

Codata was the first to offer a microcomputer-based Unix on the M68000; the first to offer APL under Unix; and more recently the first to offer a microcomputer version of BASIC compatible with Digital Equipment Corporation's powerful XBASIC-Plus.

Inasmuch as Codata has more than 500 multiuser Unix systems in the field, and is increasing that number by 50 per month, it was distressing to read that article.

Beau Vrolyk, Vice President, Marketing
Codata Systems Corp.
285 North Wolfe Rd.
Sunnyvale, CA 94086

Pascal Defended

Some computer hobbyists may, like Mr. Pournelle, be disappointed by some Pascal compilers and by the limitations of one or two of the hundreds of texts available on the subject. (See "Letters, Pascal, CB/80, and Cardfile," September 1982 BYTE, page 318.) Professional programmers, however, will rightly perceive these as superficial grounds for evaluating a computer language. They will more likely be interested in the strong points of Pascal: its emphasis upon structured techniques, its strong data typing, the flexibility of its user-defined data structures, and the mathematical elegance of its grammar (as reflected in the Backus-Naur formulation).

As one such professional, Pascal enables me to create, very quickly, highly reliable and extraordinarily complex programs for the real-time control of precision automatic machinery.

Pascal is not the end-all of computer languages (being somewhat deficient in string processing and file handling), yet it can prove a most useful tool for anyone who takes the trouble to understand its strengths. But only a fool would attempt to master Pascal in an afternoon.

Dr. Gerald Hull
RD 1, Box 85
Little Meadows, PA 18830

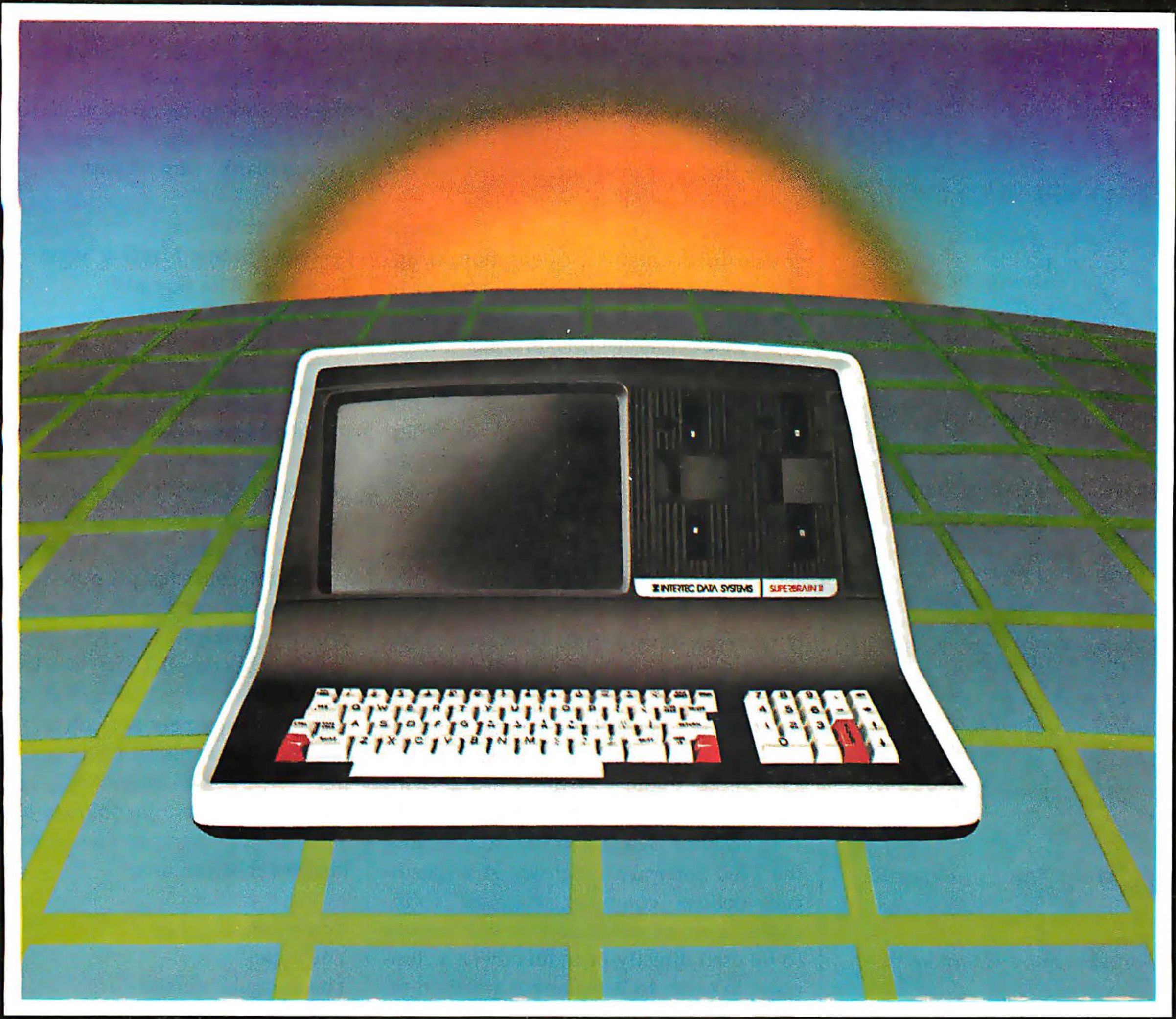
BYTE Scoops Others

Although I spend $300 per year for IEEE and ACM journals, it was BYTE that first told me about France's new World Computer Center. Keep up the good work.

William Randolph Franklin
School of Engineering
Electrical, Computer, and Systems Engineering Department
Rensselaer Polytechnic Institute
Troy, NY 12181

Letter of the Law

BYTE readers should be aware of a serious omission in Richard Stern's article regarding legal protection for object code. (See "The Case of the Purloined Object Code, Part 1: The Problems," September 1982 BYTE, page 20.) Mr. Stern proceeds from the premise that the key determination is whether the work in question is embodied in a "copy." He then argues that object code stored in a ROM (read-only memory) may not be a "copy" entitled to copyright protection under the 1976 Copyright Revision Act and under the 1980 amendment to that Act regarding computer software. Mr. Stern states (pages 430-431) that a "copy" is a tangible embodiment of a work from which it can be—as Mr. Stern quotes the statute—



Letters

"perceived . . . or otherwise communicated." He then argues that it may not make sense to say that object code can be "perceived" or "communicated" because object code is primarily intended to constitute a list of instructions for a machine, rather than an expression directed toward another human being.

Mr. Stern's quotation left out words critical to the statutory definition as applied to computer programs. According to the Act, "copies" are "material objects, other than phonorecords, in which a work is fixed by any method now known or later developed, and from which the work can be perceived, *reproduced*, or otherwise communicated, *either directly or with the aid of a machine or device*." (Emphasis added.)

I believe Mr. Stern's argument, even as stated, is tenuous, in that object code *is* intelligible (albeit with difficulty) and clearly conveys information. However, when the complete statutory definition of "copy" is considered, his argument is rendered unsupportable. There can be no question that a work in object-code form can be "reproduced" from a ROM "with the aid of a machine or device."

In addition, Mr. Stern fails to note that the 1980 Software Copyright Act specifically defines "computer programs" to include "a set of statements or instructions to be used directly or indirectly in a computer in order to bring about a certain result." By any straightforward interpretation, object code falls within this definition.

Denying copyright protection for object code would, as a practical matter, render useless the protection which even Mr. Stern concedes Congress established for source code. Most programs are distributed in object code, and, even where they are not, copyright would offer meaningless protection if a purchaser of a copy of the source code could make and market multiple copies of the object code for profit without the copyright owner's consent. An interpretation such as that urged by Mr. Stern puts an enormous loophole in the copyright protection provided by Congress. This, in fact, is exactly what was found in the most recent federal appellate decision on this subject (August 2, 1982), *William Electronics Inc. v. Artic International Inc.*, squarely upholding the copyrightability of object code.

Mr. Stern made errors in analysis in the article as well. For example, in characterizing object-code programs as "utilitarian objects," he seems to be confusing information with the medium in which the information is stored. Distinguishing the computer programs stored in a ROM from the ROM itself (i.e., the utilitarian object) should be no more difficult than distinguishing what is written in a book from a blank ream of paper.

Ronald Abramson
Fenwick, Stone, Davis & West
Two Palo Alto Square
Palo Alto, CA 94304

Solution Doesn't Fit Problem

We'd like to take issue with some comments made in Jerry Pournelle's September BYTE User's Column. He criticizes Pascal compiler systems for their handling of syntax errors. The observations are valid; however, his proposed solution is questionable and fails to address the primary problem.

A Pascal compiler can do a lot to identify and describe mistakes, but syntax correction is extremely difficult and often incorrect. For instance, Mr. Pournelle does not understand why "=" cannot be replaced by ":=" in obvious situations. This simple example illustrates the difficulties that can arise:

You want:	IF A = B
You type:	IFA = B
The compiler corrects as:	IFA := B

Many similar problems require complicated heuristics to provide reasonable corrections. The same constraints apply when inserting missing semicolons. Many people do not recognize that semicolons are statement separators, not statement terminators. Statement separators are necessary for multiple-statement lines and multiple-line statements. How many people, for example, are thrilled with FORTRAN's single statement per line restriction?

What can be done if the compiler does not remove such annoyances? Certainly, switching languages is a drastic measure. Pascal is more portable than BASIC (try moving a BASIC program written in one dialect to another BASIC system). Also, BASIC programmers encounter simple syntax errors. The interactive nature of BASIC suggests a strategy.

The approach employed in the UCSD Pascal system offers a solution. When the UCSD Pascal compiler detects an error, it invokes the editor. The location of the error is highlighted, and the diagnostic

message is displayed. The error is quickly fixed and compiling resumes. This interactive technique is very fast. Syntax checkers or pretty printers can also scan text to locate syntax errors before compiling. Syntax-directed editors are a sophisticated solution that prevents errors before they occur. Knowledge of the language grammar allows these editors to significantly reduce program text entry time.

We do not think Pascal should be "stuffed into a culvert" for the reasons outlined by Mr. Pournelle (though Pascal does have shortcomings). His comments do have merit as a critique of available software tools.

Mark A. Morely
Stephen J. Schmitt
2400 Science Parkway
Okemos, MI 48864

Jerry Pournelle Replies

Your point is well made; I shouldn't want a compiler to make that correction, and I see the problem of making one smart enough to know what I do want. Yet—though your point is well taken—the problem is, why would a practical programmer use a compiler (rather than an interpreter)? Surely there must be ways to let the computer do bean counting.

Some may program splendidly, without trivial errors. Alas, I don't. I don't program for a living, and when I want my computer to do something, I simply want a job done. Thus, simple old interpretive BASIC survives, because it gets the simple problems solved fast.

As to Pascal's portability, you talk about moving BASIC programs from one system to another: we've had terrible problems moving Pascal programs from one compiler to another on the same system! Yet for all that, I continue to work with Pascal because I too like its "philosophy"; it's the way that philosophy was implemented that I don't care for.

That's why I'm searching for the proper extensions to the standard. . .

Perhaps the SCUD (UCSD) Pascal is indeed the solution, especially on fast machines like the 68000; we're supposed to get a Sage computer that runs UCSD as the operating system, and if that solves the problem, believe me, I'll be glad to tell everyone.

Meanwhile, please read what I said, which is "there are times when I am willing to take Pascal and stuff the language into a culvert," which, I would have thought, implies that those times are outnumbered by times when I'm not so inclined—else why would I devote so much space to the language? But I can't think it hurts to chronicle the pains of a computer user in trying to learn the language. . . .

A Source for Computer Aids for the Disabled

It was very encouraging to see the September 1982 BYTE devoted to the advancements being made with computers for the disabled.

As a manufacturer of speech-synthesis products and a long-time advertiser in BYTE, Street Electronics missed the opportunity to inform BYTE readers of our dedication in that area.

A sizable share of Street Electronics' sales efforts have been directed to the disabled community, including the blind, the nonvocal, and others with various learning disabilities. The Echo II allows a blind individual to program on the Apple computer. Our Talking Terminal program turns the Apple into a terminal with features similar to those discussed in David Stoffel's article ("Talking Terminals," page 218) for a substantially lower price.

We hope BYTE readers find this information as informative as we found the September BYTE.

Andrew Clare, Vice President
Street Electronics Corp.
1140 Mark Ave.
Carpinteria, CA 93013

Passive Resistance Aids Pirates

Last year the Soviet Union paid $500,000 to steal ADABAS source code on tape in the United States because, I am told, they were unable to buy a paperback edition at W. H. Smith's in London.

But by Mr. Leach's reasoning (see "Of Paperbacks and Program Protection," June 1982 BYTE, page 28), it would appear that it is Software A. G.'s fault that the Soviets had to steal. Had it priced ADABAS at $100 instead of $100,000 the Soviets could have bought 5000 copies legally!

Similarly, am I expected to rationalize obtaining a photocopy of International Resource Development (IRD) Inc.'s industry analysis and forecast, *The Robot Market Explosion*, because $1285 for 150 pages could only be justified by gold-impregnated ink and then only if pages are embellished with solid print areas.

In thumbing through BYTE and other publications, I have come across numerous attempts at oversimplifying what, after all, is a complicated subject. Mr. Neiburger's and Mr. Pelczarski's *decisions* must not be mistaken for do-all, cure-all *solutions*. (See "Outsailing the Software Pirates," June 1982 BYTE, page 26.) Apple Computer's Mike Markkula has merely made a decision that is a far cry from a solution—and then again such a decision is easier made by a hardware vendor than a software vendor.

Attempts to solve the problem must first of all recognize what the problem is (i.e., giving due benefit to owners of intellectual property). Marc Brown in his article "New Court Created to Strengthen Patents" (*Electronics*, June 30, 1982, page 24) reports on how the U.S. Court of Appeals for the Federal Circuit can make litigation less expensive and heard by judges in the know. Bill HR 6420 seeks to punish software pirates. And Atari would not hesitate to take any pirate to court.

Why is there preference for legal protection and expensive, tedious legal redress? The answer lies in the absolute belief on the part of intellectual property owners that pirates are not pirates because they are naive or dumb. On the contrary, they are smart enough to hide behind an impractical legal quagmire. So let us look at some basic facts:

1. The price of software is not synonymous with the cost of its reproduction. In addition, the development cost must be recouped. Other factors include the applaudable desire to make money and pride in being able to charge more than the guy next door because you have a superior product. Mr. Leach is trying to enforce uniform mediocrity, which is fundamentally against the concept of free competition.

   A person buys software because it is worth it. So we have $10 software and we have $1 million software. But $1 million paperbacks are difficult to sell, and in the absence of intimidating paperwork and antipiracy contrivances, impossible to insure.

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"Paperback" software is suitable for consumer-type software. But certainly not for any old software. In fact, some publishers practice antipaperback strategy. For example, Walt Disney Productions would not license videotape (video tape is the paperback of films) distribution of full-length cartoons. Consequently, it is easy to prosecute anyone who sells *Snow White* on tape.

2. The price of software is not related to the price of hardware. You should be able to buy $100 software for the IBM 3081 and $10,000 software for the Osborne 1. Again, one buys software because it is worth it, not because it is cheap. But the same software for large computers can cost more than it does for small computers. Example, Cincom's Total for minicomputers costs $20,000 but for mainframes it may cost $100,000; not because of relation to cost of hardware, but because the mainframe user derives more benefits from its use. Similarly, software may be "free." Hewlett-Packard lets you have Image when you buy a minicomputer. Of course, you can bet your bottom dollar that this software will not run on any other machine.
3. Somewhere in the world there are people and businesses whose only source of income is the sale of software. Can you blame them for being chagrined by uncontrolled copying of their software?
4. Somewhere in the world there are people who are conspicuously, naively, or conveniently unaware that somewhere in the world there are people and businesses whose only source of income is the sale of software. So it is pointless in counting on conscience to protect your investment in software development.

   Mr. Neiburger's control of the situation—by sending updated software only to licensed users—is a good but incomplete solution. Who wants updated Pac-Man?
5. Somewhere in the world there are people who have no qualms about giving disks upon disks full of other people's software when they sell a machine. Because they derive no direct benefit from this copying, how would the law catch up with them?
6. Somewhere in the world there are people who would make money selling pirated software. It is worth it. Apple won't prosecute. Tandy won't prosecute. Papa and Mama cannot afford to prosecute. And even Mr. Neiburger would not prosecute discovered pirates; he prefers to convert them to dealers. Those not discovered get away scot-free.
7. Copyright and patent legislation is imprecise for the purpose of software property protection. Because Mr. Neiburger, for example, dishes out source code, can he prosecute someone who modifies it and then sells the modified object code? Is the modified program provable by Mr. Neiburger as a derivative of his software, or can the modifier simply say his software is reverse-engineered?

   Even then, is reverse-engineering a valid defense? If a game can be patented, who cares if you wrote the source code yourself by understanding what someone else's implementation does? The end result is the same game! The recent Atari judgment seems only to be concerned with whether it is the same game—not whether one program is a copy of the other!

   Therefore, is SB-80 an infringement on CP/M? After all, SB-80 uses the same system calls and parameters. It does what CP/M does. And, is Idris an infringement on Unix?

Clearly, we have not heard the last of software copyright and patents. Clearly, there is no panacea. Clearly, there should be no romanticism in the criticism of software pirates. But it's also clear that any legislative attempt to protect software copyright owners will not stop piracy. It merely makes more criminals. And please don't go away thinking humans by nature refrain from breaking laws. Fifty percent of working Americans drive above 55 miles per hour every day! Nobody says you cannot break laws. All it means is that you are liable to get caught if you do.

The situation, apart from being frustrating for our business, is rather insidious. A system vendor who insists on licensed copies of operating systems, languages, utilities, and applications is at a disadvantage to pirates, is assailed by prospective customers as do-gooders, and given absolutely no backup by copyright owners to handle the situation.

While the legislature is mulling over what laws to enact, I think the least copyright owners can do is to stand up. It may be expensive to sue the user of an infringed copy. But it is also not worth spending thousands of dollars to defend

Text continued on page 24

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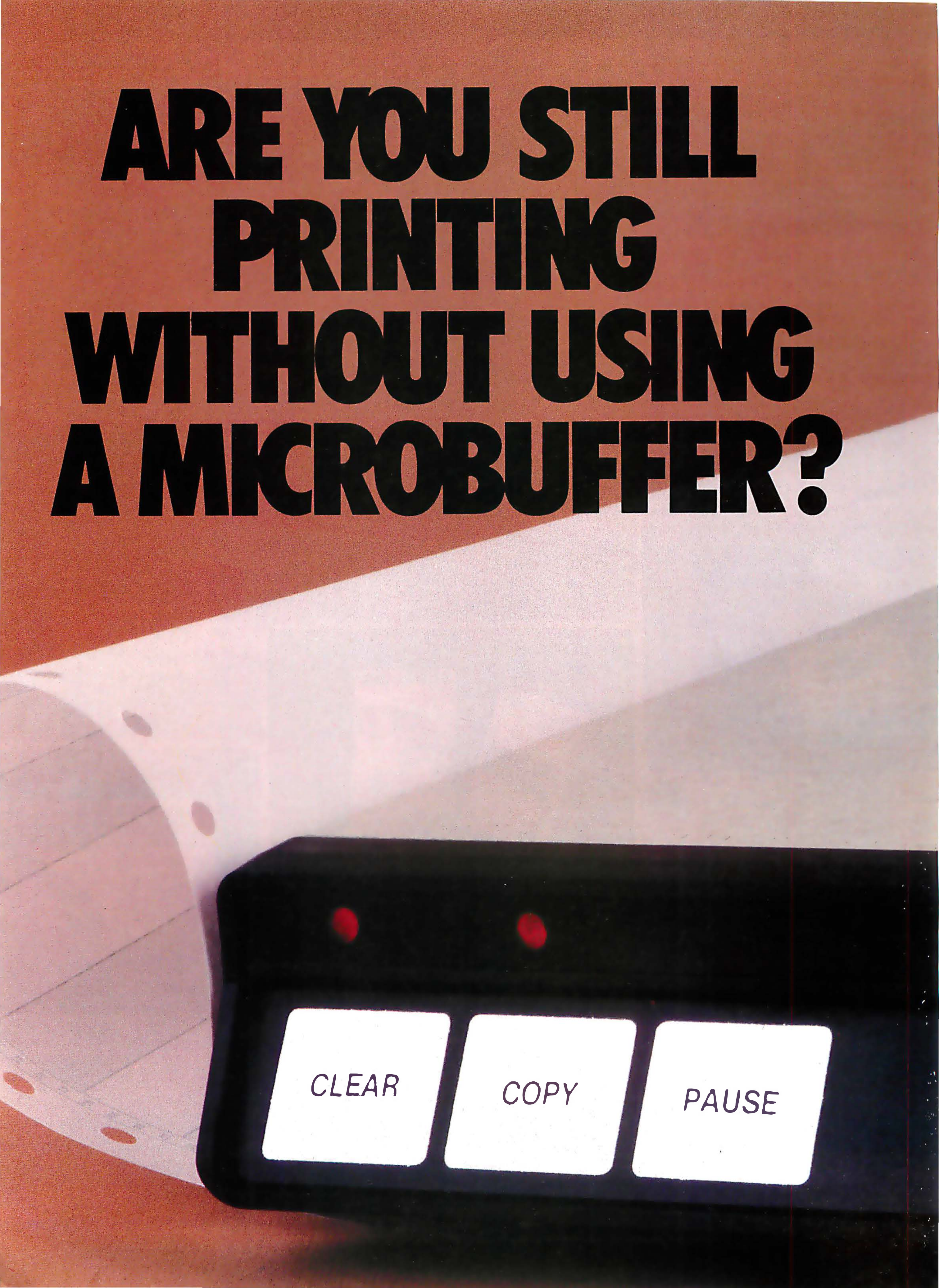
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the "savings" of $750 by using, say, pirated Microsoft COBOL.

My questions to companies like Microsoft, Digital Research, Visicorp, Softech, and others are quite simple:

- Do they agree their software is of value to licensed users and pirates alike?
- If the software is of value, would it then stand to reason that a pirate user cannot simply do without the software in his business or profession?
- Should such users be found, it would cost them plenty to either defend an infringement suit or stop using the software, making it penny wise and pound foolish to use pirated software in the first place. Therefore, will these software companies prosecute such users if the identities of these individulas are brought to companies' attention?

I guess the ball is in the court of those who are hurt most by pirates. If they do not stand up for their rights, pretty soon nobody else will.

K. C. Toh, Group Managing Director
Unidata Snd. Bhd.
6th Floor
Syed Kechik Foundation Building
Bangsar, Kuala Lumpur 22-16, Malaysia

PC Software Irksome

I recently got a personal computer after years of intermittent use of various mainframes and languages. My new computer, an IBM Personal Computer, is apparently considered a well-designed, well-implemented system. I have no complaints about the hardware except the usual ones about the keyboard. But if its software is truly well designed and executed compared with that on other microcomputers, then I am astounded. Microsoft, which wrote PC-DOS and BASIC for the machine, forces users to memorize a large amount of arbitrary material and seems to expect all users to be system programmers.

For example, most I/O statements in BASIC take arguments. I know at least four different syntaxes for specifying multiple arguments:

```
(x,y),z
x,y
x;y
(x,y)-(w,z)
```



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Letter

PC-DOS uses slashes (/) to separate some arguments and commas for others. Furthermore, commands that are common to both PC-DOS and BASIC are completely different. (DIR versus FILES, for example.)

The crowning example of an avoidable idiocy is the names of the commands for finding the cursor position. To find the line the cursor is on, use "CSRLIN". To find the cursor column, however, instead of "CSRCOL", we have to use "POS(n)". Not exactly consistent or easy to remember. And the argument (n) is only a dummy argument. It can be anything the programmer wants (i.e., the computer doesn't really need it!). My only hypothesis about why one is required is that it is intended to confuse and discourage new programmers, so that they will be forced to buy canned software.

Finally, I must mention BASIC's on-screen editor. It is wonderful. But it would have been more wonderful if Microsoft had defined the first five function keys to do what they do in EDLIN, which is the editor when you are in DOS and which has some very useful functions. Instead, you have some rarely used expressions, such as TRON and "LPT1:", to save a few fractions of a second of typing time.

I admit it: I don't like BASIC to begin with. I'm really just waiting for a decent version of APL to come out. (IBM's BASIC doesn't even support two-dimensional matrices. The ability to use *n* dimensional arrays again and to manipulate them easily will make my fingers dance with joy.) But I pity all the people who will think that writing their own programs has to be this painful.

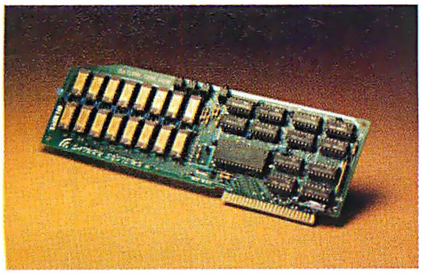
None of these problems are critical or make the machine unusable. Indeed, for someone who writes programs on it every day, they probably soon recede from consciousness as the various quirks are memorized. But why should I, who will never do much programming, have to struggle to remember or look up each function I use? Am I expecting too much? Perhaps for people who have used previous generations of microcomputers these problems are trivial compared with what they are used to. But I see no reason to accept such obvious flaws.

Roger E. Bohn
73 Boston St.
Somerville, MA 02143■



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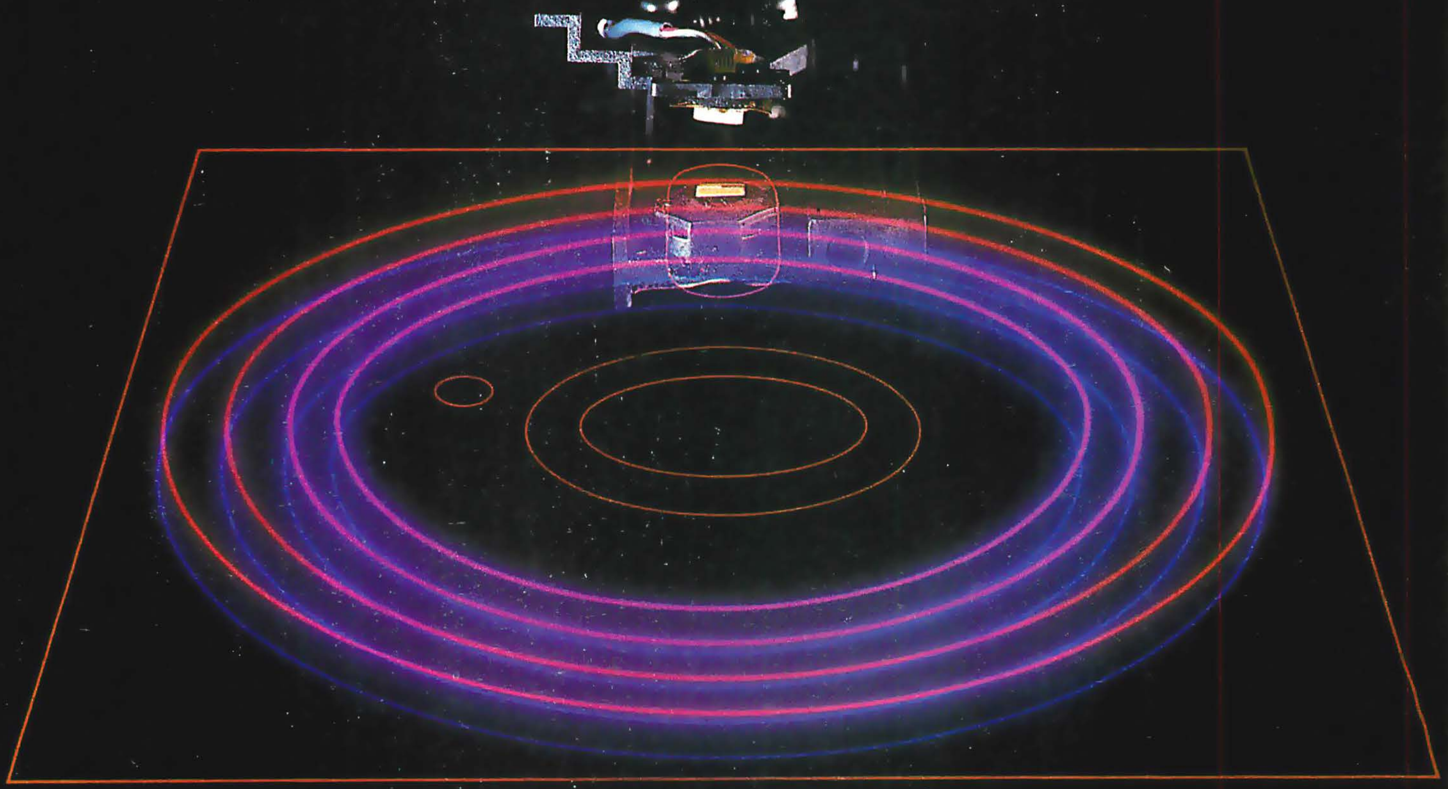
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Mark Dahmke
Consulting Editor

What emulates an IBM Personal Computer, can easily be carried from place to place, and costs a lot less than the competition? The Compaq computer, and because it can run any major business and professional software written for the IBM PC, it looks like a sure winner. I visited the Compaq Computer Corporation's headquarters in Houston recently to try out a prototype of its brainchild.

The Compaq computer is a full-function portable business computer that resembles the IBM PC in almost every way. Not only did Compaq obtain a license to use Microsoft's MS-DOS, but the company's designers also rewrote the low-level system functions used by BASIC and the operating system from the specifications required by the higher-level software. By rewriting instead of copying the code, the designers circumvented copyright infringement yet still created a computer that can run IBM PC software. This interesting approach to duplicating the functions of the IBM PC, as well as the overall quality of the machine, is a testament to the designers' engineering expertise. The designers, who came from such major microelectronic corporations as Texas Instruments, have experience in every aspect of the industry, from portable terminals to Winchester disk drives. Their efforts led to the development of a prototype Compaq in less than six months. (See photo 1.)

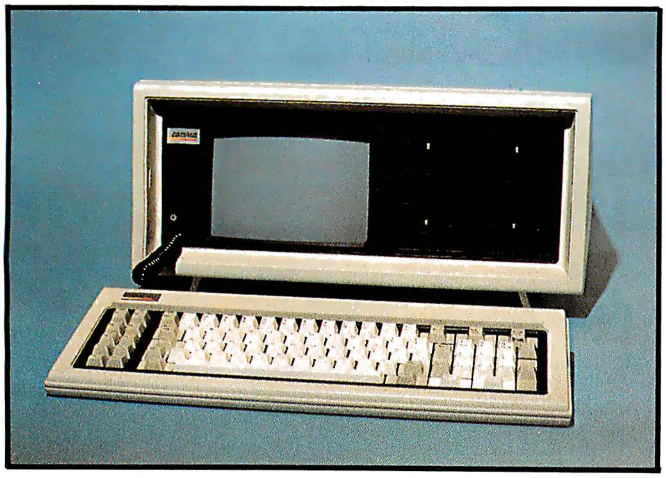
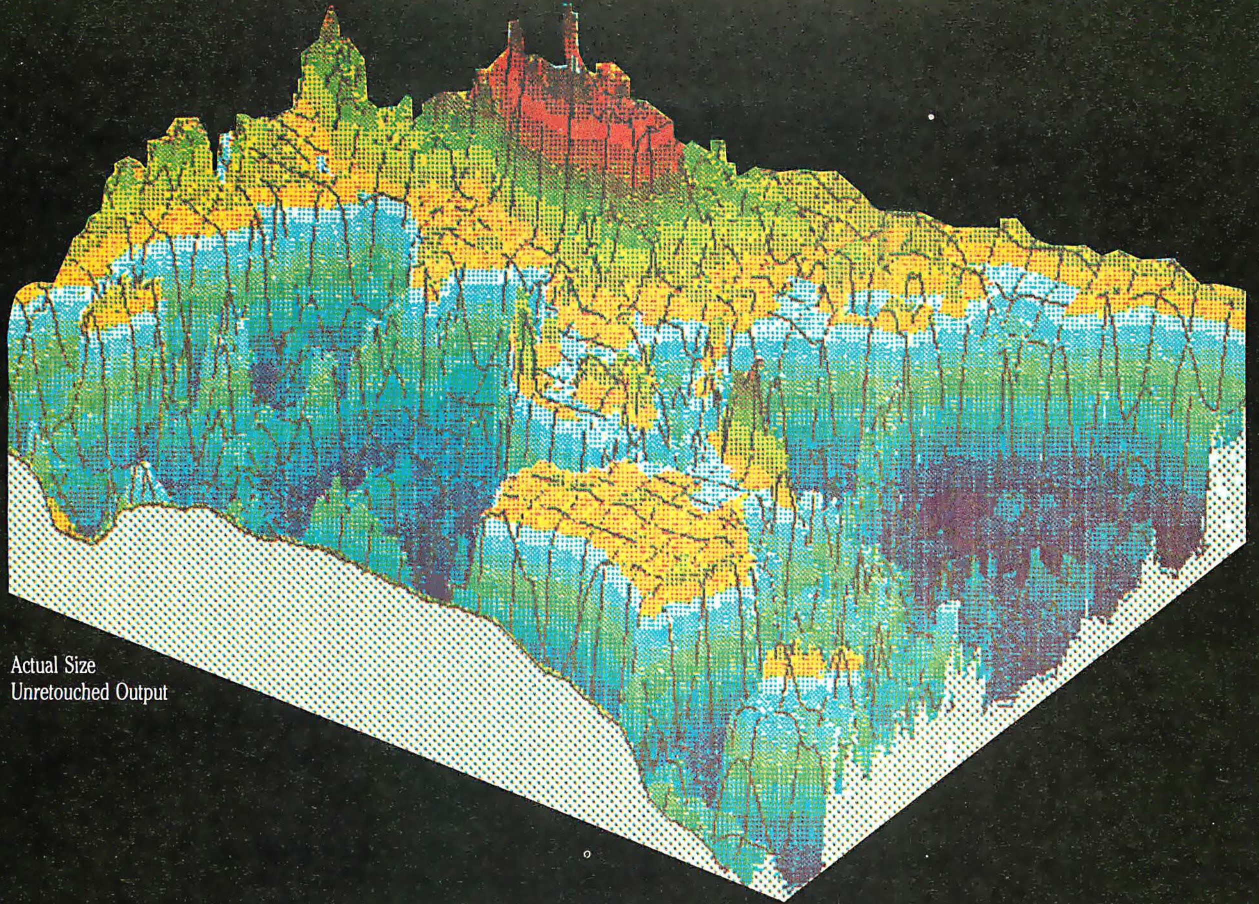


Photo 1: *The Compaq computer is a portable system that is compatible with the IBM Personal Computer and less expensive.*

The Physical Design

The Compaq computer is designed to be portable, and although it weighs 28 pounds, it achieves that goal. To transport it, you simply secure the keyboard to the main unit by locking two sliding latches. The closed case measures 20 by 8.5 by 15.3 inches and has a built-in carrying handle.

The cabinet is a plastic shell that has access panels on three sides for servicing. You can reach all of the circuit boards by removing the top panel and exposing the aluminum chassis. You can then open three main keyhole-mounted aluminum panels to reach the video display, the 120-watt power supply, the expansion slots, and the motherboard (see photo 2). The aluminum chassis, panels, and a special front panel around the video display and disk drives are elements in a design that complies with all FCC emission standards for personal computers. (In fact, an independent lab report indicates that for all frequencies tested, the Compaq was more than 10 decibels below the standard.)



Actual Size
Unretouched Output

COLOR THAT PEAKS FOR ITSELF

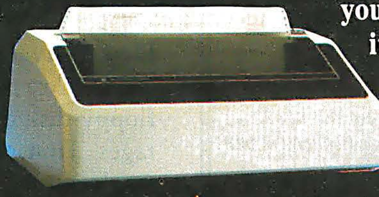
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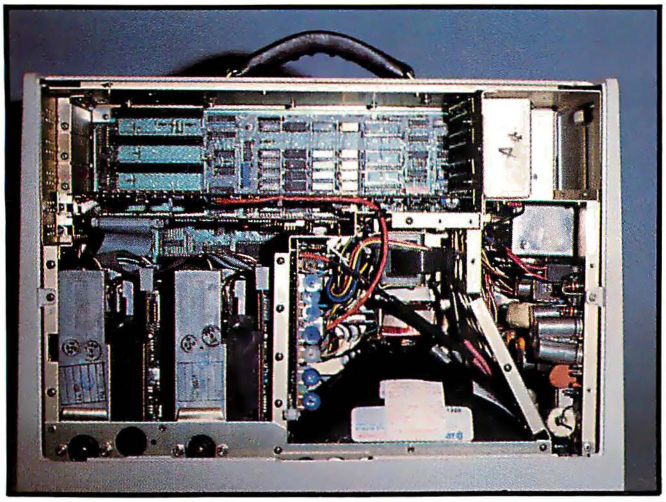


Photo 2: *By removing the top, you can easily reach the circuit boards, video display, and power supply for servicing.*

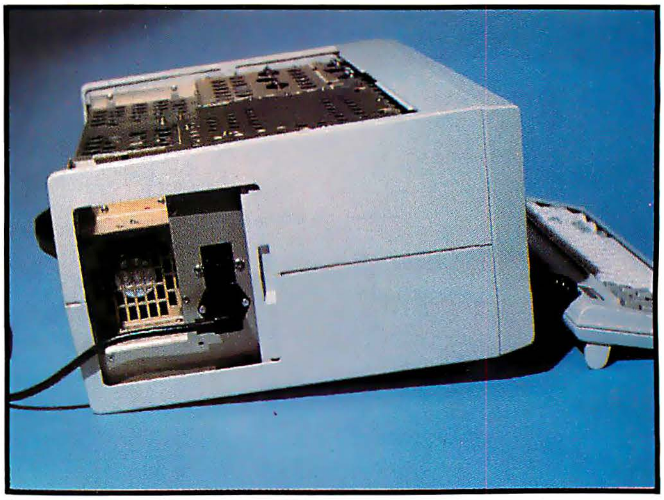


Photo 3: *A sliding door conceals a storage compartment, the power switch, and the ventilation fan.*

At a Glance

Name
The Compaq Computer

Manufacturer
Compaq Computer Corporation
12337 Jones Rd.
Houston, TX 77070
(713) 890-7390

Components

Size:	width 20 inches, depth 15.3 inches, height 8.5 inches
Weight:	28 pounds
Processor:	Intel 8088 16-bit microprocessor and socket for future addition of Intel 8087 coprocessor
Memory:	128K bytes of RAM (random-access read/write memory), expandable to 256K on the main system board
Display:	9-inch high-resolution video display; 25 lines, 80 characters; high-resolution graphics with RGB color monitor connection; adjustable viewing angle; composite video connector; RF modulator
Keyboard:	detachable 6-foot retractable coiled cord; 83 keys in IBM-identical keyboard layout; 10-key numeric pad and 10-key function pad; adjustable typing angle
Storage:	320K-byte double-sided 5¼-inch floppy-disk drive included; optional second 320K-byte drive
Expansion:	three IBM PC-compatible expansion slots; parallel printer interface included

Software
MS-DOS operating system and BASIC licensed from Microsoft; IBM PC-compatible; can run all major business and professional software packages sold for use on the IBM PC

Options
serial-interface board, 320K-byte disk drive; 64K-byte memory increments to an additional 128K bytes; light pen for use with color monitor; asynchronous communications interface

Price
$2995 for a basic system with 128K bytes of memory, one 320K-byte disk drive; $3590 for a two-disk-drive system.

On each side of the computer, you'll find a sliding door. One conceals a storage compartment for the power cord and the power switch and provides an opening for the ventilation fan (see photo 3). To plug the power cord into its standard chassis socket, you must first open the access door, which prevents the computer from overheating. The second access panel covers the expansion slots (see photo 4).

Although the Compaq keyboard is the image of the IBM PC, it is actually quite different in several respects. The Compaq's keys have a softer touch and the hard-wired click is missing. You can select your own level of audible feedback for keystrokes by simultaneously pressing the ALT key and the + or − key to raise or lower the volume from no click to a loud one. The keyboard connects to the computer by a 6-foot coiled cord that is stored in a tube built into the front of the unit. Both the computer cabinet and the keyboard have recessed feet that let you elevate the unit to a five-degree angle. You can also angle the video display five degrees.

The Compaq's floppy-disk drives have major advantages, including 320K bytes of storage capacity each.

Disk Drives

The Compaq uses Control Data Corporation 5¼-inch floppy-disk drives because they have three major advantages. First, they are much quieter than the IBM PC's single-sided Tandon drives. Second, when you turn the Compaq off, the two read/write heads remain unloaded, so they won't touch each other. For a portable computer, that's an important feature because it eliminates the possibility of the heads damaging each other in transit.


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Photo 4: *A second access panel covers the three expansion slots.*

The Brains Behind the Operation

The Compaq Computer Corporation was founded in February of 1982 by three former Texas Instruments (TI) senior managers. Rod Canion, president and chief executive officer, was manager of three different TI Product Customer Centers, where research, engineering, and marketing departments combine their efforts to create new products and bring them into the marketplace. James Harris was a vice-president of engineering who managed several key engineering and product-development efforts at TI, including 5¼- and 8-inch Winchester disk drives, the 770 intelligent terminal, and the development of bubble-memory storage for other products. Harris also shares the patent for the architecture of the TI 990 computer. William Murto, a former vice-president of marketing and sales for TI, managed business development and product planning there.

Compaq has raised more than $10 million in funding from major venture-capital firms. The lead investor was Sevin Rosen Partners, headed by Benjamin Rosen, the respected personal computer industry analyst who publishes the Rosen Electronics Letter, *and L. J. Sevin, founder of Mostek.*

While the company recommends that you insert a cardboard retainer when you transport the unit, the designers assume that most people would forget or wouldn't be able to find the cardboard when they wanted to move the computer. To offer additional protection, the drives are shock mounted. The third advantage of these drives is their storage capacity. Each double-sided disk drive holds 320K bytes of programs or data. You can still read standard IBM disks with the Compaq, but you also have the option of formatting user disks for twice as much storage as the standard IBM PC offers.

Unlike the IBM machine, the Compaq does not have a disk-drive expansion connector from the disk-interface board, but you can plug an IBM floppy-disk controller board into one of the expansion slots and add two additional drives. Finally, the Compaq, in another variation from the IBM PC, does not have a cassette interface; the Compaq's disk drive is a standard feature, so its designers chose not to include one.

Memory Capacity

The Compaq comes with 128K bytes of RAM (random-access read/write memory) soldered in to increase reliability. You can expand to 256K bytes of RAM on the motherboard. By comparison, the IBM PC comes with 16K bytes of RAM and can expand to 64K bytes on the motherboard. The design of the Compaq motherboard gives you access to the additional memory-chip sockets without requiring you to remove the board.

The large amount of RAM in the Compaq enabled its designers to omit the cassette BASIC interpreter in ROM (read-only memory), one of the IBM PC's features. With 128K bytes of RAM on the Compaq, you can use BASICA (Advanced Disk BASIC on the DOS disk) without sacrificing RAM memory space needed for programs.

Monochrome and Graphics

The Compaq improves upon the design of the IBM PC by consolidating monochrome and color graphics into one board. Hence you get the best of both worlds in one monitor display. Internally, the software always recognizes the color-graphics board and acts accordingly. When you specify the 80- by 25-line mode, however, the hardware switches to the character set of the monochrome board. The available character sets are identical to those on the IBM PC, and the Compaq has both RGB (red-green-blue) and composite-video outputs as well as an RF (radio-frequency) modulator output so that you can connect the computer to your television.

With both monochrome and color graphics on one board, you get the best of both worlds.

Ultimate Compatibility

When a company advertises a computer as being "IBM PC-compatible," the best way to test its claim is to try to load an IBM release of PC-DOS, CP/M-86, or the UCSD p-system. I didn't have the p-system, but I did have both PC-DOS and CP/M-86 and was able to try both of them on a prototype of the Compaq computer. The systems loaded and executed perfectly, with the exception of the BASIC on PC-DOS, which wouldn't execute because the Compaq doesn't have ROM BASIC. The BASICA provided on disk and all of the IBM PC sample BASIC programs found on the PC-DOS disk ran without incident. I also tried some CP/M-86 assembler-level software that I had written, and it worked without a hitch as well. I spent about an hour loading and running a number of game programs and some professional packages such as Wordstar and Supercalc. With one exception, they all worked correctly. The one that didn't was a game program that ran perfectly but died when I tried to terminate

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the game. One of the programmers told me that the problem was probably a result of not initializing the hardware correctly when the system was powered up. The company assured me that the problem would be solved before any machines were shipped.

Other Features

Several special features deserve mention. Instead of providing a connector for external disk drives, the Compaq has a parallel printer-port connector that is fully supported by all system software. In addition, the Compaq has been designed to handle 128K-bit RAM memory components as soon as they become commercially available. Many features of this computer indicate that the designers anticipated possible problems and solved them before the Compaq was announced. A case in point is the keyboard cable, which is designed to supply 12 volts instead of 5 to the keyboard, thus preventing the voltage from dropping to marginal levels at the end of its 6-foot cord. In another anticipatory design feature, the RGB monitor interface has internal jumpers that allow reverse-signal polarity for some nonstandard RGB monitors.

Documentation

I can only assume that the same level of quality that is characteristic of the Compaq computer will be found in the documentation. The company was preparing the user's manual when I looked at the Compaq, but the typeset text and numerous diagrams and tables I saw looked quite professional.

The Bottom Line

Considering all of the ways in which the Compaq improves on the IBM PC, the most significant difference between the two is price. An IBM PC with one double-sided drive (320K bytes), both the monochrome and color-graphics boards, a parallel-printer port, a monochrome monitor, and 128K bytes of RAM would cost approximately $3735. All of these features are standard on the Compaq for $2995. With this configuration, you would have only one remaining expansion slot on the IBM PC, while three slots would be available on the Compaq. All of the options are also less expensive with the Compaq. For example, an additional double-sided drive for the IBM PC would cost $650 in contrast to the $595 for the Compaq. A 64K-byte memory board costs $195 for the Compaq versus $350 for the IBM, and a serial-interface card for the Compaq costs $145, while its IBM counterpart is $150.

Conclusions

The Compaq computer has everything going for it—design, compatability, portability, and price. The only possible obstacle Compaq faces is IBM itself. IBM has a longstanding reputation for deliberately designing hardware and software that render plug-compatible products incompatible. Barring that occurrence, Compaq should do well by introducing a comparatively low-cost and portable alternative to the IBM PC. ■

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Microcomputing, British Style

The Fifth Personal Computer World Show

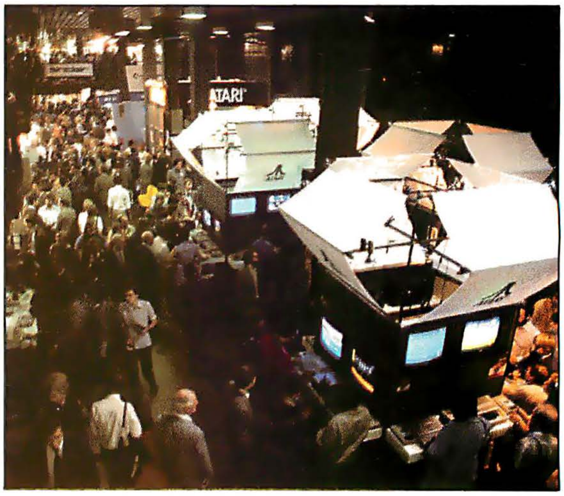
by Gregg Williams, Senior Editor

Quick: what's the most microcomputer-hungry country in the world? The United States, of course, right? We've got Silicon Valley and Route 128 (recently dubbed Technology Highway) near Boston. We've got BYTE, Apple, Atari, and IBM. True enough, but Britain has the *people*—and it has a lot more than we do.

There's ample evidence that, compared to the U.S., proportionally more of Britain's population is interested in microcomputers. The Fifth Personal Computer World Show, a business and hobby microcomputer show hosted by one of Britain's leading computer magazines, *Personal Computer World*, is a case in point. From September 9 to 12, 1982, 47,461 people attended the show—12,000 more than visited this year's West Coast Computer Faire, which also lasted four days and was—until now—the world's largest microcomputer show. If that's not enough evidence, consider that the Personal Computer World Show held at the Barbican Center in London had far fewer exhibitors and less exhibition space than the Computer Faire, yet drew roughly one-third more people. A quick check in an almanac confirms that the population of the United States is almost four times that of the United Kingdom, which makes the attendance figures even more impressive. Something rather important is happening over there.

Last September, I attended the show to observe the state of microcomputing in Britain firsthand. And if the crowds I saw in London were any indication, more Britons from a wider range of ages (still almost exclusively men and boys, though) are clamoring for microcomputers than Americans are on the basis of any American convention I've ever attended. On the weekend, I saw a line—er, excuse me, queue—of people several blocks long waiting to buy tickets. It must have taken hours to reach the window, and once inside you couldn't move or see anything.

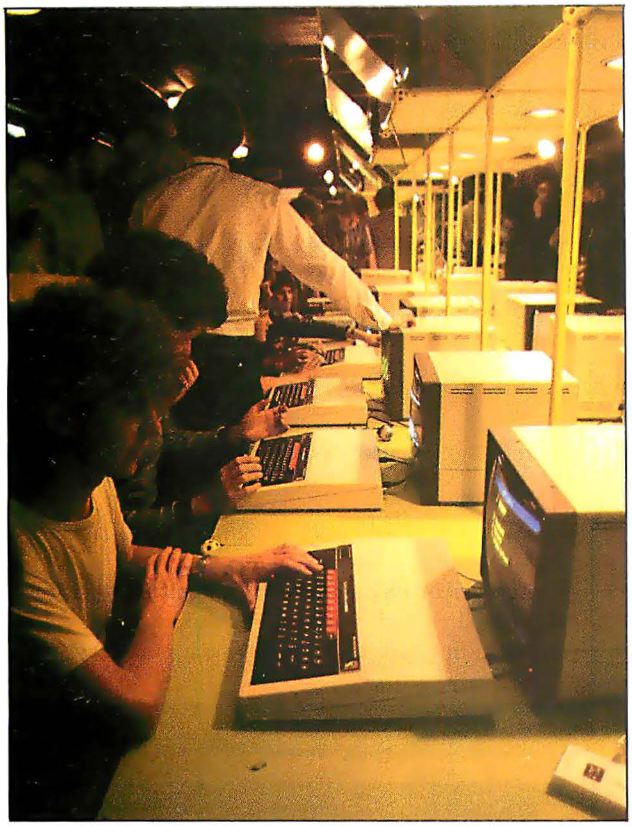
Why are the British so enthusiastic about microcomputers? Part of the answer lies in the official support of the British government, which decided that microcomputers are important enough to warrant government-sponsored public education on the subject. The British Broadcasting Corporation (BBC) sponsored a tutorial series on computers and commissioned an official microcomputer to be used in conjunction with the programs. I'm told that the television programs have been



The Personal Computer World Show on one of the slow days. You should have seen it when it got crowded! (Photos by Gregg Williams and Chris Morgan.)



The ACT Sirius 1, as popular in Britain as the IBM Personal Computer is in the United States, is said to be the Victor 16-bit microcomputer in a different housing. An entire section of the show was devoted to ACT and third-party hardware and software vendors.





Although the Personal Computer World Show had separate business and hobbyist sections, Acorn (maker of the BBC Microcomputer) had booths in both. Left: a dozen people were able to get hands-on experience with the BBC Microcomputer. Above: a screen shot of Snapper, a BBC Microcomputer game whose graphics and sound are great.



The Sinclair machines may be the most popular in Britain, but that doesn't mean that people like their keyboards—a brisk market exists for add-on keyboards and enclosures for Sinclair machines. This one, from DK'tronics, includes a full-size keyboard with keypad and an enclosure large enough to fit the computer board and other Sinclair peripherals. Its £45 price tag (almost as much as the £50 ZX81 computer) indicates the amount of interest in such products.

augmented by books and materials to be used in the public school system. A BBC series on programming is planned, and the National Extension College, a home-study institute, already has a course on BASIC programming using a generalized version of the language.

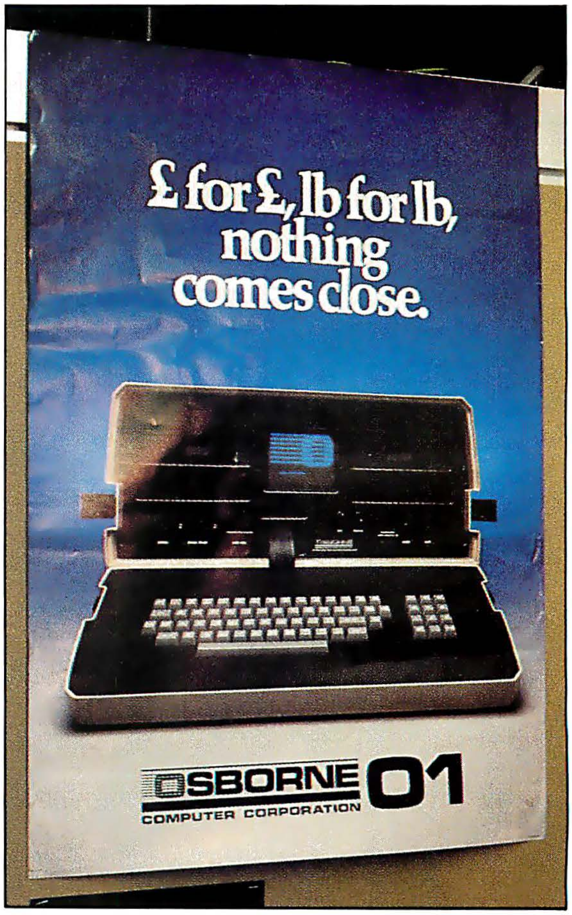
Jack Schofield, editor of another leading British microcomputer magazine, *Practical Computing*, has his own hypothesis for the popularity of microcomputers in Britain. The past decade has not been kind, economically or socially, to Britain, and as a result most people have learned to accept long lines and high prices as part of daily life. Fearful that high technology may put him out of a job someday, the average Briton has accepted the computer as a potential influence, but one that he has some control over. This, Schofield says, may explain the strong interest in microcomputers that transcends British class and economic boundaries.

Whether or not Schofield's hypothesis is correct, the British appetite for microcomputers owes a good deal to the pivotal work of one man: Clive Sinclair. As head of Sinclair Research, the company that makes the ZX80, the ZX81, and the Spectrum microcomputers, Clive Sinclair is to the British small computer what Adam Osborne is to the American business computer: the creator of a product whose price is so low that the competition finally accepted it as the price to beat. Before Sinclair brought out the ZX80 at about £100 (less than $200), the British had only expensive American imports. Discounted Commodore VIC-20s and Atari 400s, for example, sell for around £200 and £300 respectively, almost twice their American prices. Because it is so expensive abroad, the Apple II is known primarily in Britain and Europe as a *business* machine, believe it or not. American microcomputers have always been just too expensive for the average person. You can then imagine the exultation when Sinclair Research brought out the ZX80 for under £100—one-half to one-third the price of the imports. Granted, it wasn't as good a computer, but more people could afford it, and that made the difference. Now more than half the microcomputers in Britain are ZX80s and ZX81s. The ZX81 now sells for £50, and British manufacturers are interested in creating a full-featured computer for less than £300.

My first observation at the Personal Computer World Show was that people were insatiably curious about microcomputers. After that, I was impressed by the diversity of inexpensive machines. I've written short descriptions of the six machines most worthy of note—the Acorn BBC Model B, the Dragon 32, the EACA Genie III, the Camputers Lynx, the Grundy Newbrain AD, and the Sinclair Spectrum. (All but the Genie III are low-cost machines.) I've included a chart that compares those computers, a collection of photos from the show, and a list of addresses for all the products mentioned in this article. So lean back and enjoy the show—at least *you* don't have to fight the crowds.■



Here's a 3-inch disk pack for the Grundy Newbrain AD computer. The Newbrain disk-drive module houses two 3-inch disk drives in a small unit the size of the computer itself—in fact, the disk-drive module is meant to fit unobtrusively under the computer.



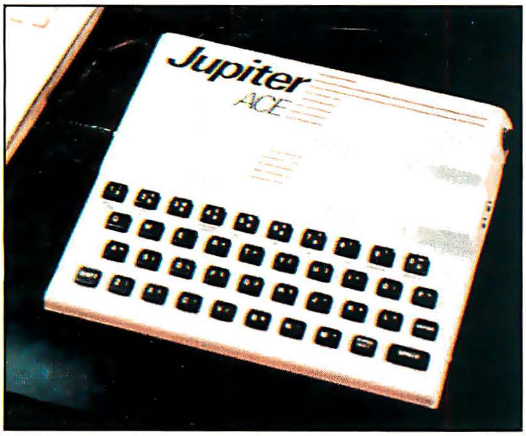
The Osborne computer is very popular in Britain. (Actually, I'm a sucker for a clever ad.)



A section of the show was devoted to the Third European Chess Championship, a tournament among microcomputer chess programs. Tournament rules stipulated that all machines average 30 moves per hour, a computational limit that put several computers at a disadvantage.



The Microwriter is one of the most interesting devices I saw at the show. A one-handed data-entry unit, it can be hooked up to a printer or a microcomputer, and it even has some limited word-processing features. You enter data by pressing down and releasing certain combinations of the six buttons. At £557.75 (less than $1000). it's a bit expensive, but its portability and one-handed operation make it desirable to some.



Even more interesting than the Microwriter is the Jupiter Ace, a low-cost microcomputer that has FORTH instead of BASIC in ROM. Any resemblance to the Sinclair Spectrum is not accidental; Steve Vickers and Richard Altwasser, who designed the Ace, were the codesigners of the Spectrum and are now running their own company. The Jupiter Ace is a very interesting implementation of Forth Interest Group FORTH with some innovative extensions to adapt it to a cassette-only environment.



These stamps, issued recently by the British Post Office, reflect Britain's commitment to and awareness of computers in everyday life.



The Sinclair Spectrum

If Clive Sinclair's black-and-white ZX80 and ZX81 have become the most popular microcomputers in Britain (and, for that matter, in the rest of the world), is it any wonder that his company's new color microcomputer, the Spectrum, is doing just as well?

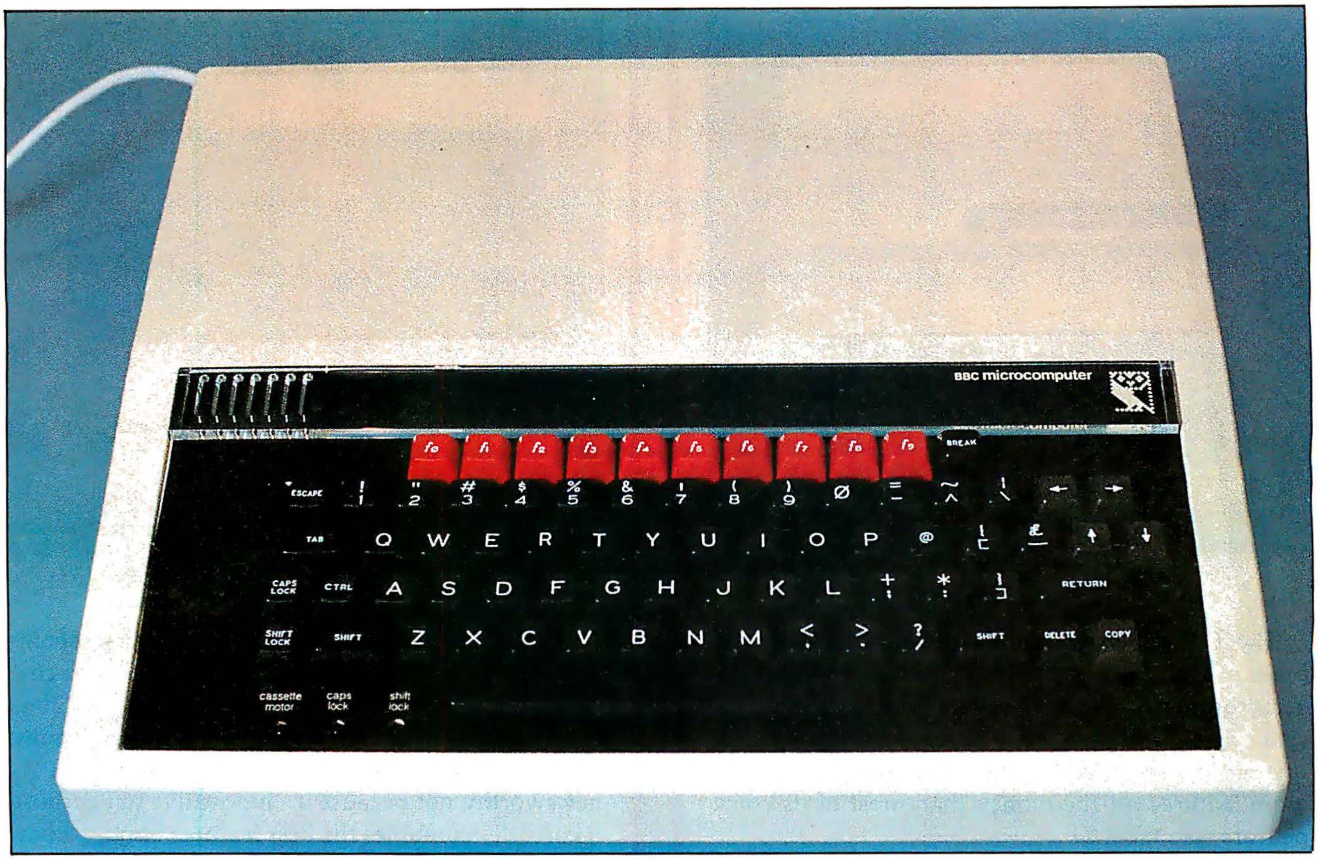
The success of the Spectrum is a source of great comfort to Clive Sinclair, especially since the BBC chose Acorn's design over his for use in its computer-literacy program. (Incidentally, Sinclair could be accused of the same tactic for which he had berated Acorn: advertising the product long before he was able to deliver it.) As the British ad for the Spectrum points out, the Spectrum is markedly simpler and more elegant than the Acorn BBC Microcomputer when measured by the number of chips on its main circuit board. However, the Spectrum shows a quirkiness that is the price we pay for its circuit board elegance and low cost. And Clive Sinclair's statement that the Spectrum is "less than half the price of its nearest competitor—and more powerful" is only half right: half the price, yes, but definitely not more powerful.

First of all, you have to consider the keyboard. For £125, we can't quite demand the full keyboards offered by machines that are considerably more expensive than the basic Spectrum. Given the price differential, we can make allowances for the Spectrum's unique keyboard, which is basically a pressure-sensitive membrane (like those of the ZX80 and ZX81) mounted under a piece of molded gray rubber that protrudes above the plastic cover to make "keys." This interesting scheme works surprisingly well, but the cramped 9.3-inch-wide keyboard has other faults that are harder to excuse.

Inexpensive or not, the keyboard layout is impossible to justify. It may be innovative, but it's also poorly designed in several respects. The layout is clever in that you can use it to enter letters, numbers, one-stroke BASIC keywords, graphics symbols, and the like. But that scheme makes the keyboard busy. Most keys have five legends: three printed on the key and one each immediately above and below the key. This design may be necessary, but it also causes eyestrain and confusion. I'd be willing to forgive all this, but I can't excuse such thoughtless "innovations" as providing only one Caps Shift key (in the lower left-hand corner; the one on the right is used as a Symbol Shift key) and placing the space key in the lower right-hand corner of the keyboard.

The Spectrum's BASIC is a superset of the Sinclair BASIC used in the ZX80 and ZX81, and it has some valuable features, most of them having to do with the rather clever way graphics are implemented. ZX81 cassette tapes will not load on a Spectrum, and most

Continued on page 50



The Acorn BBC Model B Microcomputer

The BBC Microcomputer enjoys a colorful reputation because of its history. (See "The BBC Computer," *Popular Computing,* October 1982.) More than two years ago, the BBC decided to start a computer literacy television series. The network realized that, with more powerful and increasingly inexpensive microcomputers, it would soon be possible to create them with enough computing power to offer their owners personal hands-on experience with microcomputers at an affordable price. The BBC considered the Newbrain computer and rejected it. Acorn and Sinclair Research, along with other companies, then submitted designs, and the Acorn won. (Sinclair went on to market its design as the Sinclair Spectrum.) Clive Sinclair has been quick to point out problems with the Acorn unit, and the interaction between the two companies has been a source of entertainment for the British computer community.

Although the BBC Model B is more expensive than some units (see page 49), it has an advantage over most of the very-low-cost ones: it is a no-compromise computer that has many uses beyond self-instruction in computer technology. I will confine my remarks to the Model B unit instead of the less expensive Model A (at £299) because the latter lacks most of the features that make the BBC Microcomputer competitive with other similarly priced units.

The BBC Model B has eight video-display modes, five pixel-graphics modes in which you can display text, and three text-only modes. The highest graphics mode (640 by 256 pixels, 2 colors) requires a video monitor, while the lowest one (160 by 256 pixels, 4 or 16 colors) offers roughly the same resolution, practically speaking (i.e., once the image is displayed on a standard color television) as the Apple and Atari computers, but it also offers additional colors.

The most innovative feature of both BBC computers is the Tube, a special interface built into the computer that enables the main computer (which uses a 6502 board) to communicate with any suitably designed auxiliary microprocessor board. This is, not coincidentally, a way for Acorn to provide a Z80 board so that the BBC computer can run business software available through Digital Research's popular CP/M operating system. At first, the Tube sounds like the Microsoft Consumer Products' Softcard for the Apple II, but the connection it uses is different. The Softcard and similar boards share the address and data lines with the main microprocessor. The Tube, however, uses a dedicated 2-MHz serial link with memory buffers on each side of the link and interrupt-driven software. This scheme allows true coprocessing with both processors running at full speed. Acorn has plans to

Continued on page 51



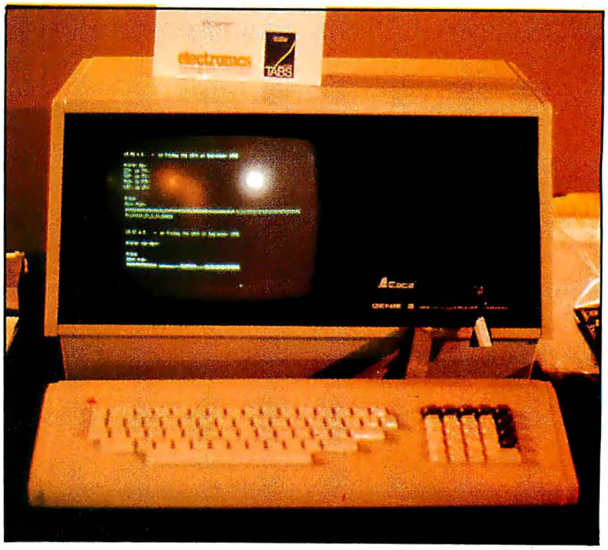
The Dragon 32

The Dragon 32 is named for its standard 32K bytes of memory—quite a selling point in a country accustomed to microcomputers with memories as small as 1K bytes. And because the Dragon 32 is one of the newest British microcomputers, it offers more features for the money than most of its competitors (see table 1).

The Dragon 32 seems to be a very adequate machine, but there's nothing exceptional about it. In fact, I can sum it up in one sentence: it looks like a Radio Shack TRS-80 Color Computer with 32K bytes of memory. (I've found that some Color Computer cartridges will run on the Dragon 32, but they must be taken out of their plastic shells to fit in the Dragon 32 cartridge slot.) Its similarities to the TRS-80 Color Computer include use of the 6809E microprocessor and Microsoft's Extended Color BASIC (right down to command names—PMODE, HEX$, and DEFUSR, for example), nine colors for color graphics display, five graphics modes, joysticks, and cartridge software.

The Dragon 32, however, does have several advantages over the TRS-80 Color Computer. First, in Britain it is considerably cheaper than the Color Computer. Second, the Dragon 32 can be expanded to a full 64K-byte workspace (unlike the Color Computer, which can only be expanded from 16K to 32K bytes of memory). Third, the Dragon 32 has a typewriter-style keyboard that is somewhat better than the TRS-80 Color Computer's adequate but calculator-like keys. Finally, the Dragon 32 includes a Centronics-type parallel-printer port.

Dragon Data Ltd. plans to market its computer in America but hasn't decided on a date. You can be sure the company will take care of its home market before expanding internationally. When that happens, American buyers will have a choice of low-cost color computers.



The EACA Genie III

The Genie III is the only one of the six microcomputers profiled here that doesn't fall in the low-cost category. I included it because, of all the business machines at the show, it's the one that caught my eye. Like the IBM Personal Computer, it is newsworthy not because it's innovative but because it carefully combines the best features of other computers. It is manufactured by EACA International and distributed in Britain by Lowe Electronics.

The Genie III is housed in two units. The main one contains the computer itself, a 12-inch green-phosphor video display, and two 5¼-inch double-sided 80-track floppy-disk drives. (These can be augmented by either two 5¼-inch or two 8-inch floppy disks.) The other unit is a detachable 86-key keyboard, which includes a numeric keypad around whose two edges eight function keys are wrapped.

Emulation capabilities are the Genie III's main claim to fame. It is supplied with two operating systems, NEWDOS-80 version 2.0 and CP/M 2.2. If you load NEWDOS-80, the BASIC loaded is a RAM (random-access read/write memory) version of Radio Shack TRS-80 Model I BASIC supplied (legally) by Microsoft; the video display shows 16 lines of 64 characters each, and the machine emulates a TRS-80 Model I. If you load CP/M, the video display shows 24 lines of 80 characters each, and the machine emulates a CP/M system with a standard screen size. (Under software control, NEWDOS can also use the 24 by 80 video format.)

Table 1 lists some of the Genie III's features. Its built-in real-time clock, optional high-resolution graphics (288- by 640-pixel) board, and optional programmable-character interface board are also of interest. With additional hardware, the Genie III can support multiple users and run Digital Research's MP/M operating system. You can also add an external 5-megabyte hard disk.



The Grundy Newbrain AD

In the July 1982 issue of *Personal Computer World,* managing editor Dick Pountain writes, "When the Newbrain was announced to the world two years ago, the design concept was significantly in advance of anything that had been seen in the field of handheld computing." And so it was—even though problems plagued the design. In fact, the company that created it, Newbury Labs, sold the design to its current owner, Grundy Business Systems Ltd. At one time, the Newbrain was in line to be the BBC computer, but design problems and the change in ownership caused the BBC to look elsewhere.

The machine is now being advertised as a compact but powerful microcomputer, and the number of hardware and software features and options it offers supports this point of view. The Newbrain AD, which contains a 16-character fluorescent display, is complemented by a cheaper version, the Newbrain A, which sells for £199. The Newbrain M, a third model that includes a battery-backup option, is scheduled to be released soon.

The basic unit includes a Z80A microprocessor that runs at 4 MHz, a National Semiconductor COP 420M microprocessor dedicated to handling input and output, 32K bytes of RAM, and 29K bytes of ROM (read-only memory). Through an external expansion box, you can increase this to a staggering 2 megabytes of RAM and 4 megabytes of ROM. Grundy plans to market the CP/M operating system and popular applications-software packages in ROM, which will convert the Newbrain to a "crashproof," stand-alone computer dedicated to one task. The keyboard has calculator-type keys in a standard configuration; the spaces between keys are just slightly smaller than those on a standard typewriter keyboard. The Newbrain video-display character set contains 512 letters, numbers, and graphics as well as videotex symbols. The character set is divided into two 256-character banks, only one of which can be selected at a time.

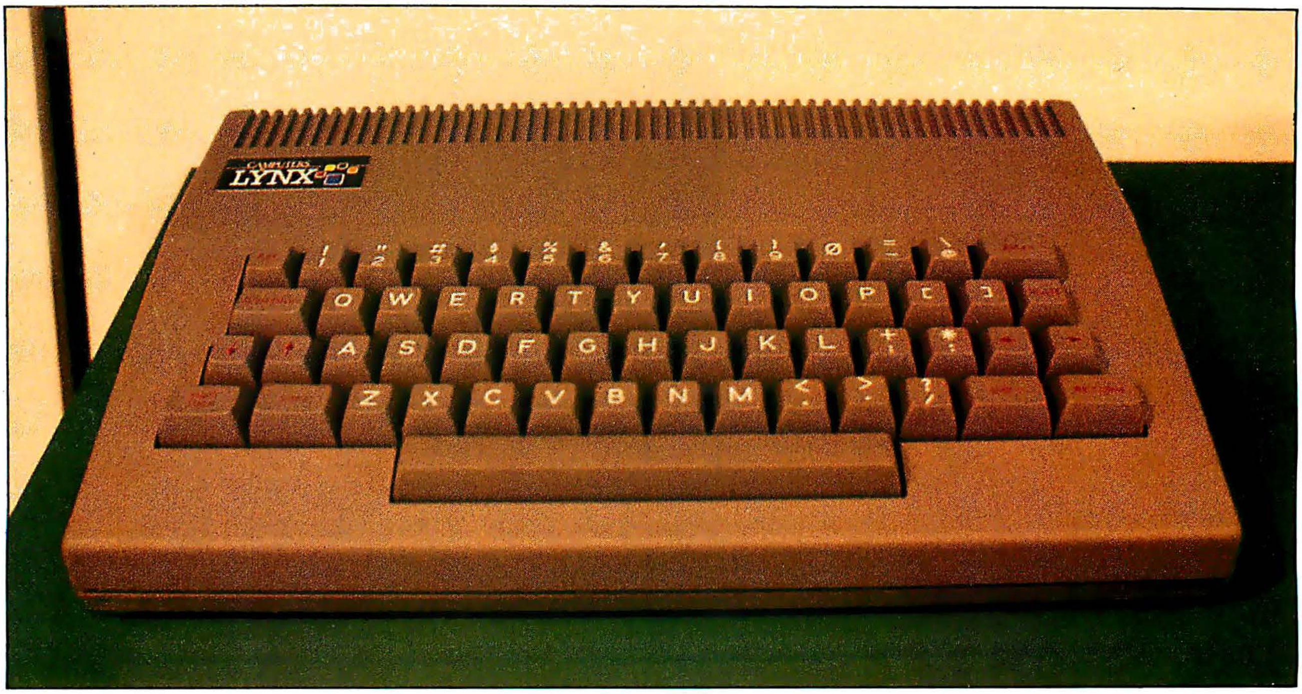
A Multiple Communication/Network Module adds 8, 16, or 24 (depending on the model) RS-232/V24 bidirectional serial ports. According to the manufacturer, Newbrains connected through this module constitute a de facto network that can share floppy or hard disks, printers, and other peripherals.

An optional Videotex Module enables Newbrain owners to access British Teletext and Prestel services.

The Newbrain produces a monochrome text or graphics video image. The machine offers a choice of several pixel densities: 256, 320, 512, or 640 pixels per row. In addition, you can split the video display into separate graphics and scrolling-text areas (with text above graphics); a graphics-only display has 250 rows of pixels.

The Newbrain software is equally versatile, if confusing on occasion. The 29K bytes of ROM contain the Newbrain operating system as well as its BASIC,

Continued on page 51



The Camputers Lynx

The Lynx, from Camputers Ltd., is one of the newest machines I saw in England. "Previewed," not announced, at the Personal Computer World Show, it offers more computing power for the money than any other machine I saw there.

The unit itself is almost Spartan in appearance and size, but it has some rather attractive features. The keyboard, which houses the entire computer, is full-sized and conventionally laid out. Unfortunately, the Delete key is where the Return key usually is, and the Return key is, oddly enough, to the right of the right Shift key. The Lynx comes with 48K bytes of memory, but it can be expanded to an impressive maximum of 192K bytes. The computer runs a Z80A microprocessor and can optionally run CP/M. It has a good 40-character, 24-line video display that converts to an 8-color, 248- by 256-pixel graphics display. With additional memory, video resolution doubles to 80 characters per line and 248- by 512-pixel graphics. I was told that the unit allows user-defined characters.

Representatives from Lynx say a 5¼-inch disk drive will be available for the unit and that the company will eventually market an adapted version of the machine in the United States.

Vendor List

Ace: *Jupiter Cantab, 22 Foxhollow, Bar Hill, Cambridge CB3 8EP, England. Telephone 0954-80437.*

BBC Models A and B: *Acorn Computers Ltd., Fulbourn Road, Cherry Hinton, Cambridge, England. Telephone 0223-245200.*

Cambridge Ring (network system): *Orbis Computers Ltd., 4a Market Hill, Cambridge CBZ 3NJ, England. Telephone 0223-312449.*

Dragon 32: *Dragon Data Ltd., Queensway, Swansea Industrial Estate, Swansea SA5 4EH, England. Telephone 0792-580651.*

Genie III (British distributor): *Lowe Electronics, Bentley Bridge, Chesterfield Rd., Matlock, Derbyshire, DE4 5LE England. Telephone 0629-2430.*

Genie III (manufacturer): *EACA International Ltd., EACA Industrial Bldg., 13 Chong Yip St., Kwun Tong, Kowloon, Hong Kong. Telephone 3-896323.*

Lynx: *Camputers Ltd., 33a Bridge St., Cambridge CB2 1UW, England. Telephone 0223-315063.*

Microwriter: *Microwriter Ltd., 31 Southampton Row, London WC1B 5HJ, England. Telephone 01-831-6801.*

Newbrain A and AD: *Grundy Business Systems Ltd., Grundy House, Somerset Rd., Teddington TW11 8TD, England.*

Sirius: *ACT (Sirius) Ltd., 111 Hagley Rd., Edgbaston, Birmingham B16 8LB, England. Telephone 021-454-8585.*

Spectrum: *Sinclair Research, 6 Kings Parade, Cambridge, Cambridgeshire CB2 1SN, England. Telephone 0276-685311.*

ZX81: *see Spectrum, above.*

ZX80/ZX81/Spectrum enhanced keyboard and enclosure: *DK'tronics, 23 Sussex Rd., Gorleston, Great Yarmouth, Norfolk, England. Telephone 0493-602453.*

How They Compare

	BBC Model B	Dragon 32	Genie III	Lynx	Newbrain AD	Spectrum
Price (pounds, including Value Added Tax)	£399	£199	£2185	£225	£229	£125
Microprocessor used	2 MHz 6502	6809E, speed unknown	4 MHz Z80A	4 MHz Z80A	4 MHz Z80A	3,5 MHz Z80A
Standard RAM	32K bytes	32K bytes	64K bytes	48K bytes	32K bytes	16K bytes
Maximum RAM	32K bytes (see note 1)	64K bytes	64K bytes (see note 2)	192K bytes	2 megabytes	48K bytes
ROM included	16K bytes	16K bytes	2K bytes	16K bytes	29K bytes	16K bytes
Text display (columns, rows)	40 by 24 or 80 by 25	32 by 16	64 by 16 or 80 by 24	40 by 24 (see note 3)	40 by 30, or 80 by 30	32 by 24
High-resolution graphics display (in pixels)	640 by 256	192 by 25	160 by 72, optional 640 by 288	248 by 256 (see note 3)	640 by 256	176 by 256
Number of colors available	16	9	monochrome only	8	monochrome only	8
Type of keyboard	full-size typewriter style plus function keys	full-size typewriter style	full-size typewriter style plus keypad and function keys	full-sized typewriter style	full-sized keyboard with calculator-style keys	smaller-sized keyboard with rubber membrane keys
Subjective rating of keyboard (1 = unacceptable, 10 = excellent)	8	7	8	6 (see note 4)	7	3 (see note 5)
Interfaces included (excluding TV output)	RS-423 serial parallel port, RGB monitor output, 8-bit I/O port, four 12-bit analog input channels	parallel port joystick and cartridge ports, color monitor output	RS-232C and parallel ports	RS-232C port	two RS-232C ports, composite	none
Disk drive available?	yes	yes	two 5¼-inch drives (800K bytes each) included	yes	yes	yes
Other features	high-speed serial link for second processor	includes Extended Microsoft Color BASIC	detachable keyboard, runs NEWDOS-80 and CP/M 2.2	optional Videotext module		

Note 1: Acorn is working on a 16-bit processor with 128K bytes of RAM that connects to the BBC Model B computer via a high-speed serial link; this would bring the computer (in an unconventional way) to 160K bytes of RAM.

Note 2: In the multiuser system, the Genie III has 192K bytes of memory.

Note 3: With an optional expansion box, the Lynx can display 24 rows of 80 columns each and 248 by 512 pixel graphics.

Note 4: The Lynx keyboard suffers from having a Return key to the right of the right Shift key and a Delete key where the Return key would be on most keyboards.

Note 5: The Spectrum has a very idiosyncratic keyboard that is partially excusable because the unit is so inexpensive. See the main text for more details.

Sinclair Spectrum continued from page 44:
ZX81 BASIC programs will require some modification to work.

Sinclair used his earlier computers as a testing ground for several original features. Some of these (like the "intelligent" cursor that prevents you from entering syntactically incorrect BASIC statements) have remained in the Spectrum, while others (like the nonstandard character code used in the ZX80 and ZX81, abandoned for the ASCII code in the Spectrum) are mercifully absent.

The character-oriented video image is 24 lines of 32 characters each. Each character has a separate attribute byte (each one of eight colors, chosen independently) that determines its foreground and background colors, brightness, and flashing/steady status. The screen is always in the bit-mapped graphics mode (192 by 256 pixels), and characters are "painted" onto the video display in a pixel pattern. (This makes possible unrestricted mixing of text and graphics as well as an OVER command that merges a character string with whatever image is already on the screen.)

Actually, it's easiest to think of the video screen in terms of monochrome pixel graphics (i.e., each pixel is either on or off), with each 8- by 8-pixel square (character) having its own foreground and background color. Using the metaphor of images being "printed" on video "paper," the BASIC commands INK and PAPER set the foreground and background, respectively, of the next character to be printed. Unfortunately, this scheme restricts the color combinations of two adjacent pixels (unlike most high-resolution graphics schemes, which allow two adjacent pixels to be almost any color pair). The Spectrum also has 21 user-defined characters, each of which can be defined via special BASIC commands (thus simplifying the process more than other microcomputers).

Like the ZX81, the Spectrum has a rear-edge connector that contains a full set of address, control, and data lines. The Spectrum will accept the same ZX printer that the ZX81 uses, but, unlike the ZX81, it is upgraded to its maximum 48K bytes of memory via an internal 32K-byte board and won't work with the ZX81 16K-byte memory pack. Other peripherals in the works from Sinclair are a £20 RS-232C/network interface board and a £50 3-inch disk drive. The company's Microdrive (as it is called) is noteworthy because it costs well under $100. Each 3-inch floppy disk can hold up to 100K bytes of data; its average access time is 3.5 seconds, and its data-transfer rate is 128K bits per second.

How will the Spectrum fare in the American market? That depends. Timex Corporation has the rights to market the Spectrum (it already markets a modified ZX81 as the Timex/Sinclair 1000). If the Spectrum were to sell for the equivalent of £125, its price in Britain, it would cost roughly $220 in the United States—hardly competitive with comparable low-cost American units. My guess is that Timex will market an American version of the Spectrum for somewhere between $125 and $175 within

the next six months.

In any case, the Spectrum is a promising machine. I'll reserve further judgment until it becomes available here in the United States.

Acorn BBC Microcomputer continued from page 45:

offer 6502 and Z80 auxiliary boards and is experimenting with a board containing National Semiconductor's 16-bit 16032 chip.

Acorn is offering an interface to its Econet local network system that will make it possible to hook up as many as 254 microcomputers using inexpensive 4-wire telephone cable. Orbis, a subsidiary of Acorn, supports the Cambridge Ring (developed at the Cambridge University Computer Laboratory), a high-speed local network in a ring configuration that can connect to anything from mainframes to microcomputers.

BBC BASIC is closely modeled after the de facto standard Microsoft versions, but it adds several good extensions. The most important of these are local variables, subroutines that pass parameters, and recursion. BASIC has always been severely handicapped because it lacks these features (especially the first two), and I applaud the BBC's inclusion of them in the language. (Language designers, especially Microsoft, take note.) Another fascinating feature is a built-in 6502 assembler that allows 6502 assembly-language code in a BASIC program—bravo again! How Acorn got these and many other features into a 16K-byte BASIC, I'll never know.

The BBC Model B includes an RS423 serial port, which is said to be an RS-232C-compatible interface that facilitates a higher data-transfer rate and a longer maximum cable length than the RS-232C. In addition, the Model B includes an 8-bit Centronics-type parallel port, an 8-bit input/output (I/O) port, an RGB (red-green-blue) color-monitor output, and four 12-bit analog-to-digital ports.

Although some other British microcomputers offer more features for a given price, none of them surpasses the BBC Model B microcomputer in terms of versatility and expansion capability. Acorn has plans to produce a version of its computer for American use but has not yet set an availability date.

Grundy Newbrain AD continued from page 47:

mathematics package, screen editor, graphics package, and device-driver software. The BASIC conforms to the ANSI (American National Standards Institute) x3.2/78 standard instead of the more common de facto Microsoft BASIC standard. The Newbrain's graphics package combines traditional point-to-point drawing with Logo-like "turtle" commands (e.g., move-forward-drawing-a-line and rotate-pen-to-new-facing-angle). In addition, commands that draw arcs and fill areas with color are available.

The most useful commands relate to *data streams*, which are the "pipeline" through which all data transfer occurs. As with the Atari 400 and 800 computers, all input and output is handled through the operating system. This procedure accomplishes two things: first, it allows I/O to be handled in a standard way, regardless of the language or hardware involved; second, it is an open-ended approach that lets you write software interfaces that will work with any hardware you connect the machine to. Up to 255 data streams can be open at one time. For example, multiple data streams opened to the Newbrain screen editor give you multiple graphics "pages" that can be written to and displayed independently.

The Newbrain is obviously a complex, capable machine designed with open-ended expansion in mind. I personally do not like its small size, and its design is sometimes too complex. I would, however, want to examine it more carefully before making a final decision on it. ■

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Build the Circuit Cellar MPX-16 Computer System

Part 3

The final installment describing the design of the MPX-16, which is I/O-compatible with the IBM Personal Computer.

Steve Ciarcia
POB 582
Glastonbury, CT 06033

This month's article is the last of three on the construction of the Circuit Cellar MPX-16 computer, which is built around the Intel 8088 microprocessor. In part 1, I presented an overview of the system and a discussion of the coprocessors and bus structures. Last month, in part 2, I described the memory, interrupt mechanism, expansion bus, and I/O- (input/output) decoding sections. This month I'd like to finish by describing the serial and parallel I/O, counters and timers, the floppy-disk interface, and an overview of certain parts of the CP/M-86 operating system.

Because the MPX-16 is somewhat more complex than the typical Circuit Cellar project, I've had to simplify or abbreviate my treatment of many details to fit the articles into only three issues of BYTE; to learn some nuances of the individual system parts, you should consult the references I have listed on page 82. (More detailed information on the MPX-16, including timing diagrams and listings, is available in the *MPX-16 Technical Reference and User's Manual*, available from The Micromint.) But these articles contain enough information for you to understand the basic functions of all the subsystems and how they work together. And most of what you can learn applies also to the IBM Personal Computer and other similar machines. We'll continue the presentation after we review the major features of the MPX-16.

Most of what you can learn about the MPX-16 applies also to the IBM Personal Computer.

MPX-16 Features

The Circuit Cellar MPX-16 computer system, shown in photo 1 on page 56, fundamentally consists of a single 9- by 12-inch five-layer printed-circuit board (containing 120 integrated circuits), to which various peripheral devices are attached. Its I/O-expansion bus is completely compatible with that of the IBM Personal Computer but has nine expansion positions instead of five.

The MPX-16 uses the Intel 8088 microprocessor and the optional Intel 8087 numeric coprocessor; the main circuit board has room for 256K bytes of user memory and contains two serial and three parallel I/O ports, a floppy-disk controller, and EPROMs (erasable programmable read-only memories) containing the BIOS (basic input/output system) module of Digital Research's CP/M-86 16-bit disk operating system. The MPX-16 can be expanded by plugging in various circuit boards and interfaces

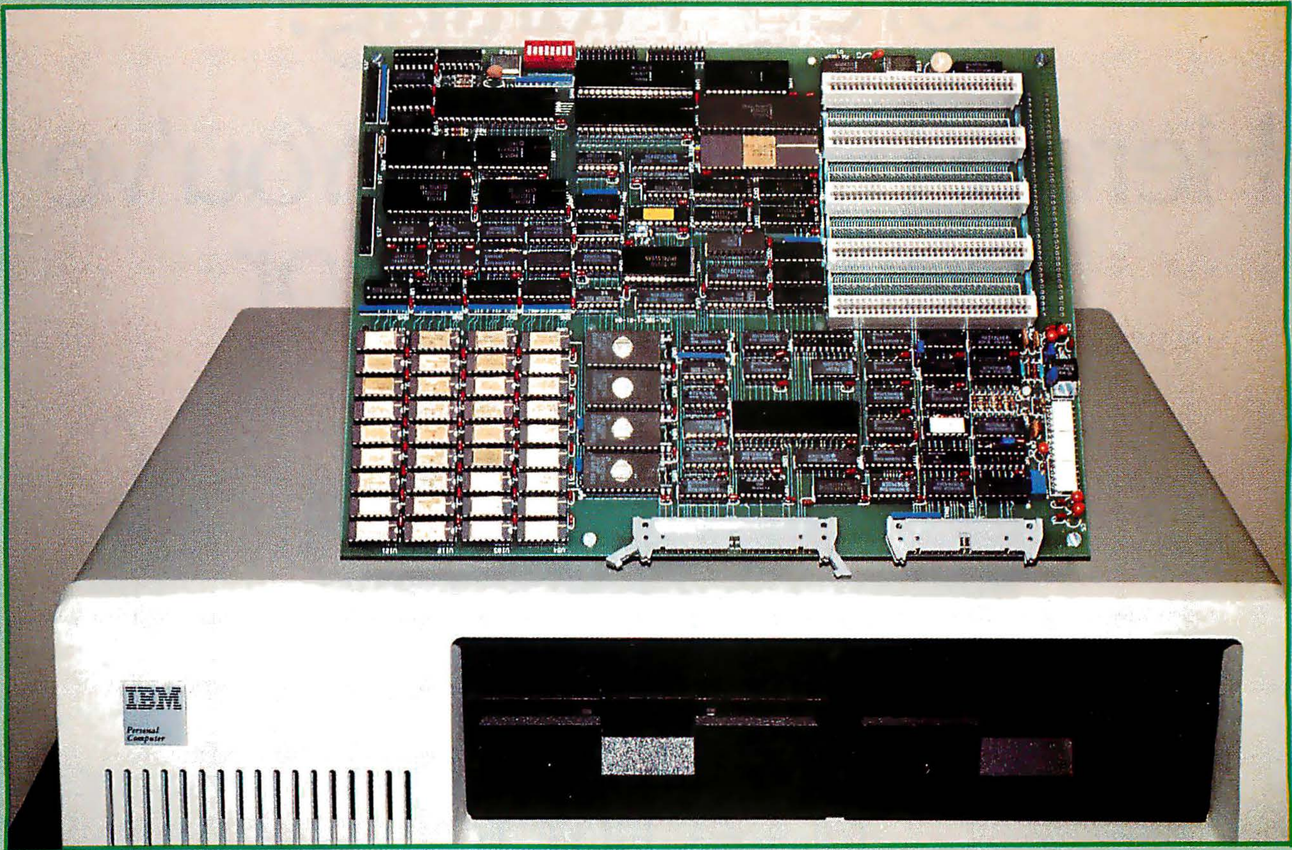


Photo 1: *The MPX-16 has been designed to be compatible with the IBM Personal Computer in that peripheral devices made for use with the IBM PC can be plugged into the I/O-expansion bus of the MPX-16.*



Photo 2: *This keyboard, made by Key Tronic Corporation (Building 14, Spokane Industrial Park, Spokane, WA 99214), is nearly an exact copy of the keyboard of the IBM Personal Computer.*

to provide a full megabyte of user memory and additional external mass storage. A more detailed list of characteristics appears in table 1 on page 59.

The MPX-16 was initially designed to run CP/M-86, but eventually Microsoft's MS-DOS operating system will be available for it, making it possible to run most software written for the IBM Personal Computer on the MPX-16, except software that uses unique features of the IBM machine. The principal difference is this: with the present operating-system BIOS, the MPX-16 communicates with the user through a serially interfaced display terminal instead of through a memory-mapped video display. In theory, you could plug an IBM Display Adapter into one of the expansion slots and connect a serial keyboard (such as the Key Tronic model shown in photo 2) for exact

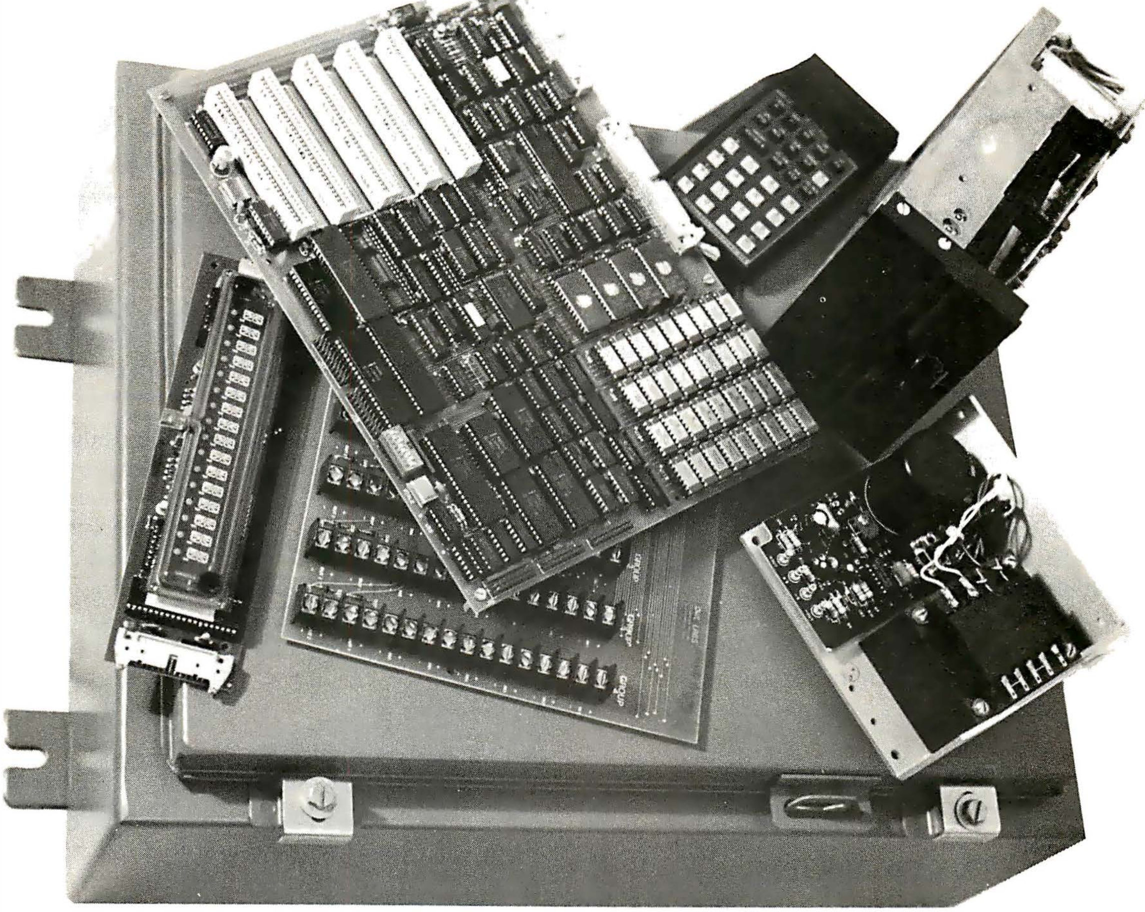


Photo 3: *Blasts and flying fluids won't faze an MPX-16 computer protected by a Hoffman heavy-duty NEMA 12 enclosure. (Photo courtesy of Owl Electronic Laboratories Inc.)*

hardware emulation.

The MPX-16 is well suited for use as a low-cost 8088-based computer for integration into a complete hardware/software package chiefly because it combines so many functions on a single printed-circuit board. Putting together the hardware of a complete system, you need only add a power supply, a serial video-display or printing terminal, and one floppy-disk drive (either 5¼- or 8-inch). By the time you read this, an enclosure for the circuit board should be available. Many applications need nothing more.

Photo 3 shows the MPX-16 along with all the other components needed to create an industrial control system, including a NEMA 12 (a National Electrical Manufacturers Association specification) enclosure, which should protect it from any environment you'd want to operate it in.

Parallel I/O Interface

The MPX-16 System Board supports four independent parallel I/O ports; of these, two are dedicated to single purposes and two are available as general-purpose I/O ports. The two dedicated ports use the Intel 8255A-5 programmable peripheral interface (PPI), which appears as IC60 in section 4 of the schematic diagram, figure 1 on pages 60 and 61. The other two ports are implemented using the Intel 8155H-2 chip, IC47 in figure 1, which contains two I/O ports, a 14-bit counter/timer circuit, and 256 bytes of read/write memory. (This memory is not used in the MPX-16. I've written about the 8155 before; see reference 3.) The relationship of the parallel I/O subsystems with the global system bus structures can be seen in the system block diagram (see figure 2 in part 1, November 1982 BYTE, pages 84 through 86). Most notably, the 8155 communicates over the local address/data bus shared with the processors, while the 8255 receives its data through the buffered resident data bus.

One of the dedicated ports is used during system initialization to read the settings of DIP (dual-inline pin) switches SW1 through SW8, which form an 8-bit system-configuration value. The eight lines of the configuration switches drive the port-A lines of the 8255. These lines are initialized by the power-up software initialization routine as input lines in the 8255's operating-mode 0 (basic input/output). The operating system can read the switch settings via an input instruction from I/O address hexadecimal 1A0. Data bits 0 to 7 in the value obtained contain the respective settings of SW1 to SW8.

The second dedicated parallel port in the 8255 is normally set up as a

1. designed to use a 5-MHz Intel 8088 microprocessor, which combines a 16-bit architecture with an 8-bit bus interface and has 20-bit addressing capability for up to 1 megabyte of system memory, operating in maximum mode to support multiprocessing
2. optional Intel 8087 math coprocessor
3. onboard space for four 64K-byte banks of dynamic RAM for a total of up to 256K bytes, with parity generation and error detection.
4. sockets for up to 64K bytes of JEDEC 24- or 28-pin standard ROM or EPROM devices
5. two RS-232C serial interface ports
6. two 8-bit general-purpose parallel I/O ports with handshaking control lines
7. one Centronics-compatible parallel printer port
8. four programmable timers (one for a real-time clock, two for data rates, one for memory-refresh requests)
9. four independent DMA (direct memory access) channels
10. sixteen levels of vectored, prioritized interrupt control
11. single- or double-density floppy-disk controller for controlling up to four 5¼-inch or 8-inch drives
12. five 62-pin I/O-expansion-channel connectors (hardware compatible with the IBM Personal Computer) with space for four more
13. five-layer 9- by 12-inch printed-circuit board
14. BIOS for CP/M-86 in EPROM

Table 1: *Features of the MPX-16 computer system.*

Centronics-compatible printer port. This second port can also be used as a general-purpose 15-bit parallel interface with 10 output lines and 5 input lines. Fourteen of the I/O lines are connected to the port-B and port-C lines of the 8255. All 15 lines are buffered and connected to the 20-pin Bergstik connector J15. The 10 output lines from port B and bits 6 and 7 of port C drive sections of the open-collector buffers IC77 and IC78. The 5 input lines are buffered by IC77 and IC76, with pull-up resistors on the input lines to allow for use of open-collector drivers on the other end. Signal-return paths are provided on pins 14 through 18 of J15.

The two nondedicated parallel ports, which communicate to the outside world through the two 20-pin Bergstik connectors J16 and J17, are implemented with the 8155H-2, IC47. These two identical I/O ports, each with 11 I/O lines (three of which are used for handshaking control), are initialized by the software initialization routine as one 8-bit output port (J16) and one 8-bit input port (J17). Because these ports are meant to be used for varying purposes, the application software of the user will typically reinitialize the 8155 to suit the application. This is accomplished by writing a new control word into the 8155's command/status register located at I/O address hexadecimal 1C0.

Serial Interface

The MPX-16 system board contains two independent RS-232C asynchronous serial I/O ports (also known as serial channels). These are primarily intended to be used in connecting the system to video-display terminals, but they may be attached to any compatible RS-232C devices. One of the serial channels (CH0) has been defined as the console I/O port for the CP/M-86 operating-system software. The second serial port (CH1) is available for user-defined applications.

The two RS-232C serial ports are implemented with Intel 8251A USARTs (universal synchronous/asynchronous receiver/transmitters), as shown in figure 1. An 8251A is capable of transmitting and receiving simultaneously at different data rates; however, the MPX-16 system requires that the same rate be used for both transmitting and receiving. A split-speed application may be supported by using both serial ports, programmed to operate at different rates.

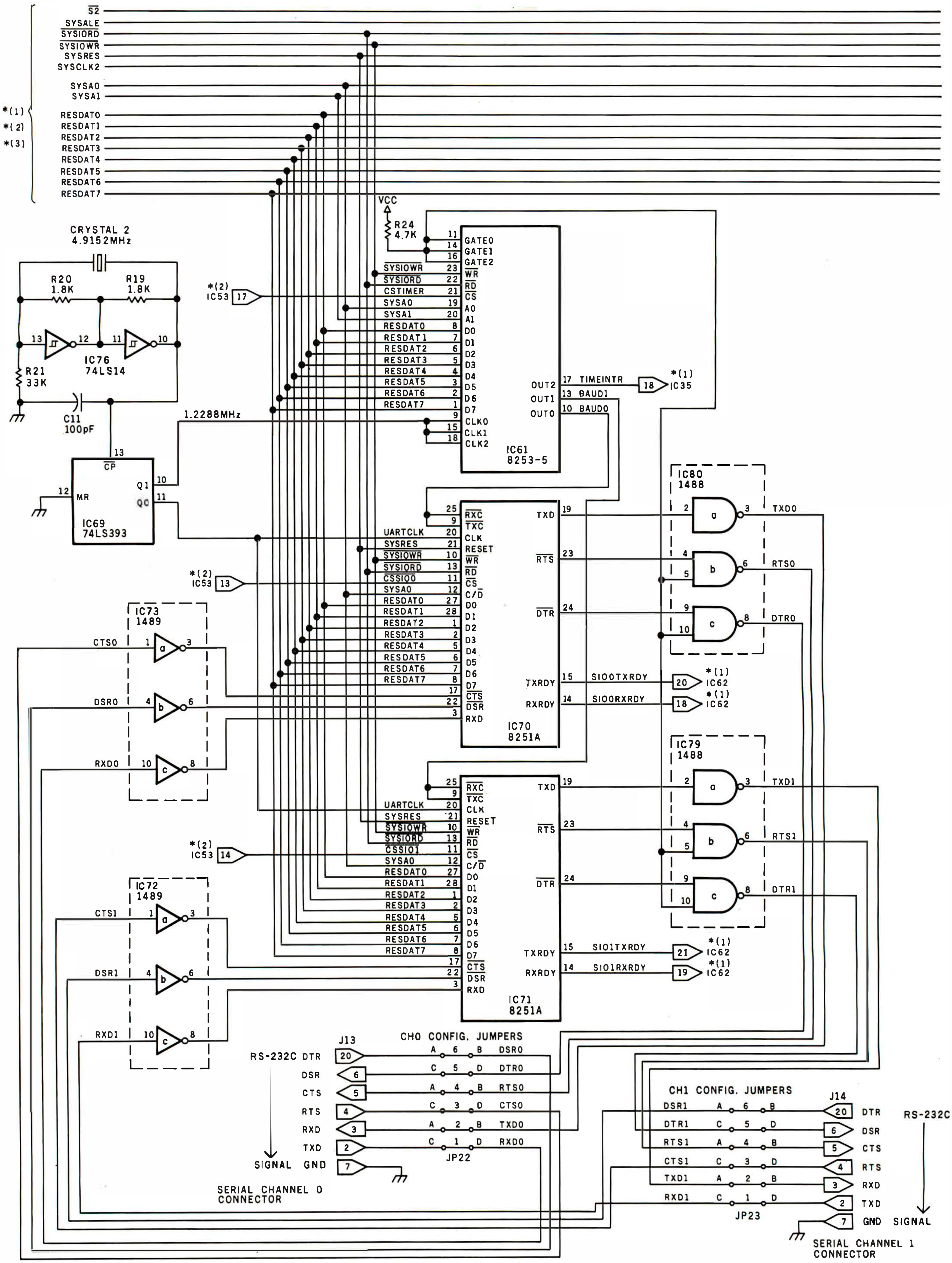
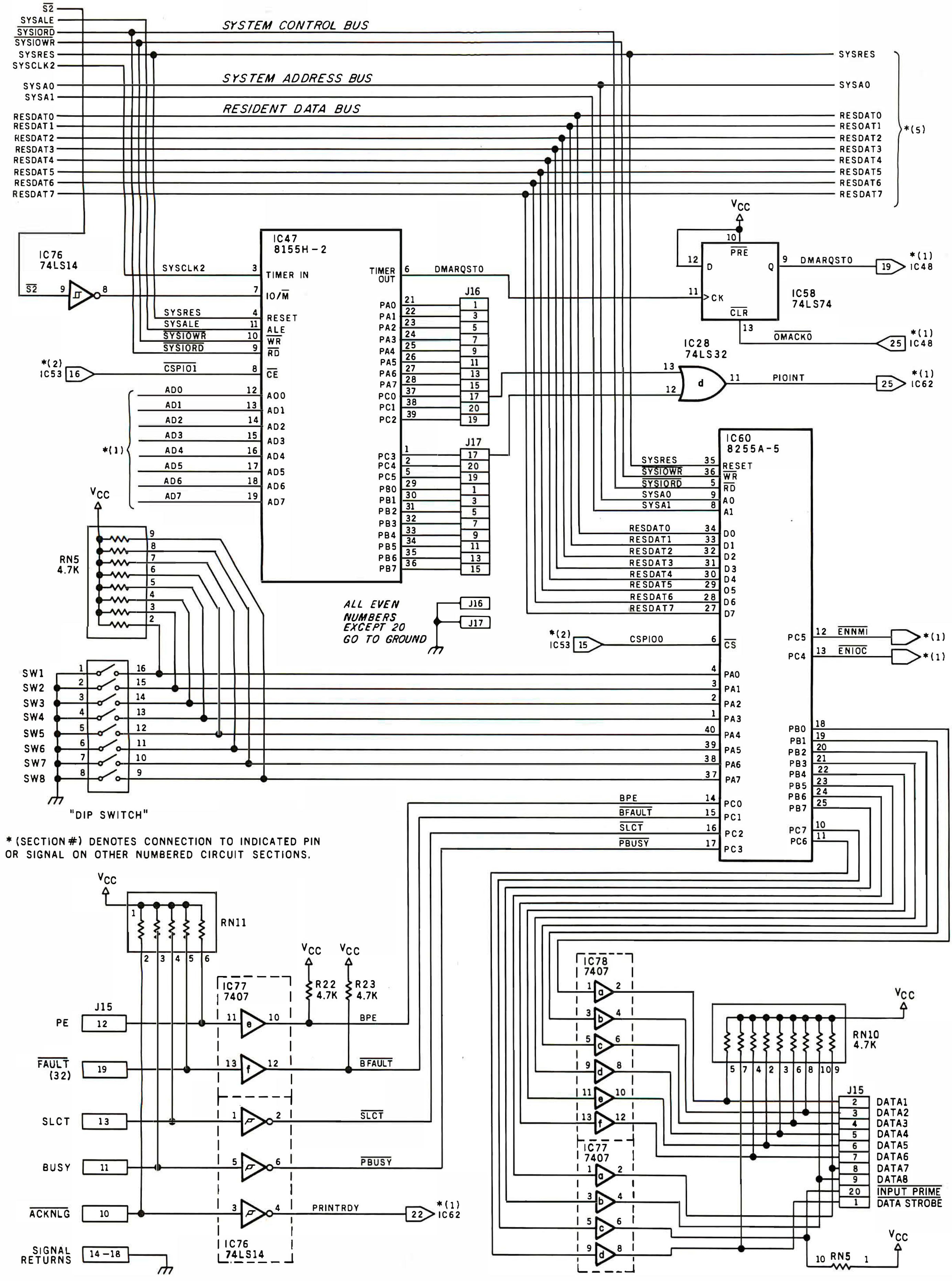


Figure 1: *Section 4 of the schematic diagram of the MPX-16 computer. Section 1 appeared in November's article; sections 2 and 3 appeared in December's article. Connections to other sections of the schematic are shown by the notation *(n), where n is the number of the other section.*



Here are shown the interface circuits for the serial and parallel I/O ports: the 8251A USARTs and the 8255A-5 and 8155H-2 parallel-interface components.

Both transmitter-ready and receiver-ready interrupt-request signals are generated during communication sequences. These signals are fed into interrupt-request lines IR0, IR1, IR2, and IR3 of the slave 8259A programmable interrupt controller, IC62 (which appeared in section 1 of the schematic diagram in November's article). The channel-0 interrupts have priority over the channel-1 interrupts, and the receiver-ready interrupt requests have priority over the transmitter-ready requests.

Both types of request signals are active-high. The receiver-ready interrupt request, which signals the main processor that a character has been received and converted to a parallel format, is obtained from the 8251A USART's RXRDY output line. Similarly, the transmitter-ready interrupt request, which signals the processor that the 8251A is ready to transmit another character to a peripheral device, is taken from the TXRDY output line of the 8251A. (Each USART also provides four control lines that can be used for modem control.)

Counter/Timers

Four independent counter/timers are found on the MPX-16 system board. All four are used for dedicated system functions and generally should not be used for other purposes. Three of these counter/timer circuits are part of the Intel 8253-5 programmable interval timer (PIT), IC61. The fourth one is the timer section of the 8155H-2, IC47, which was discussed above. All of the counter/timers are visible in section 4 of the schematic diagram, figure 1.

The 8253-5 PIT contains three independently programmable 16-bit counter/timer circuits capable of clock rates of up to 2 MHz (megahertz). These counters can be operated in any of six different modes: terminal-count-interrupt generator, programmable one-shot, rate generator, square-wave generator, software-triggered strobe, and hardware-triggered strobe.

On the MPX-16 system board, all three counter/timers of the 8253 PIT are programmed by the power-up-initialization software routine to

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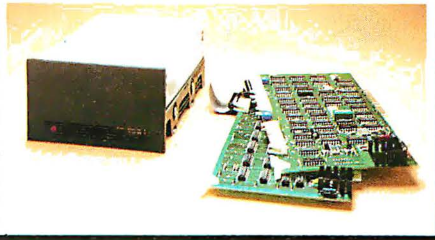
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operate in mode 3 (square-wave generator). The input clock signal that drives all three of the 8253's counter-clock-input lines is obtained from a simple crystal-controlled oscillator circuit consisting of a 4.9152-MHz crystal, a couple of inverter gates, a few resistors, and a capacitor. The output of this circuit, a 4.9152-MHz square wave, is then divided down by a 74LS393 binary counter to form a 2.4576-MHz USART clock and a 1.2288-MHz clock to drive the 8253 PIT counters.

The first counter circuit of the 8253 PIT is used as a software-programmable data-rate generator, producing a signal called BAUD0. Similarly, the second counter circuit is used to produce the data-rate signal BAUD1. The data rate for both serial channels is set at power-up for 9600 bps (bits per second) using a data-rate multiplier factor of 16. The system software then automatically initializes the data rate for the console serial channel (channel 0) when the user types a Return character in ASCII (American Standard Code for Information Interchange). The first character must be Return for proper data-rate initialization. If the input data rate of the console terminal is not 9600 bps, the program reinitializes the counter-1 circuit of the 8253 to match the new data rate.

So that system crashes will not occur, the memory-refresh signal must never be altered by application software.

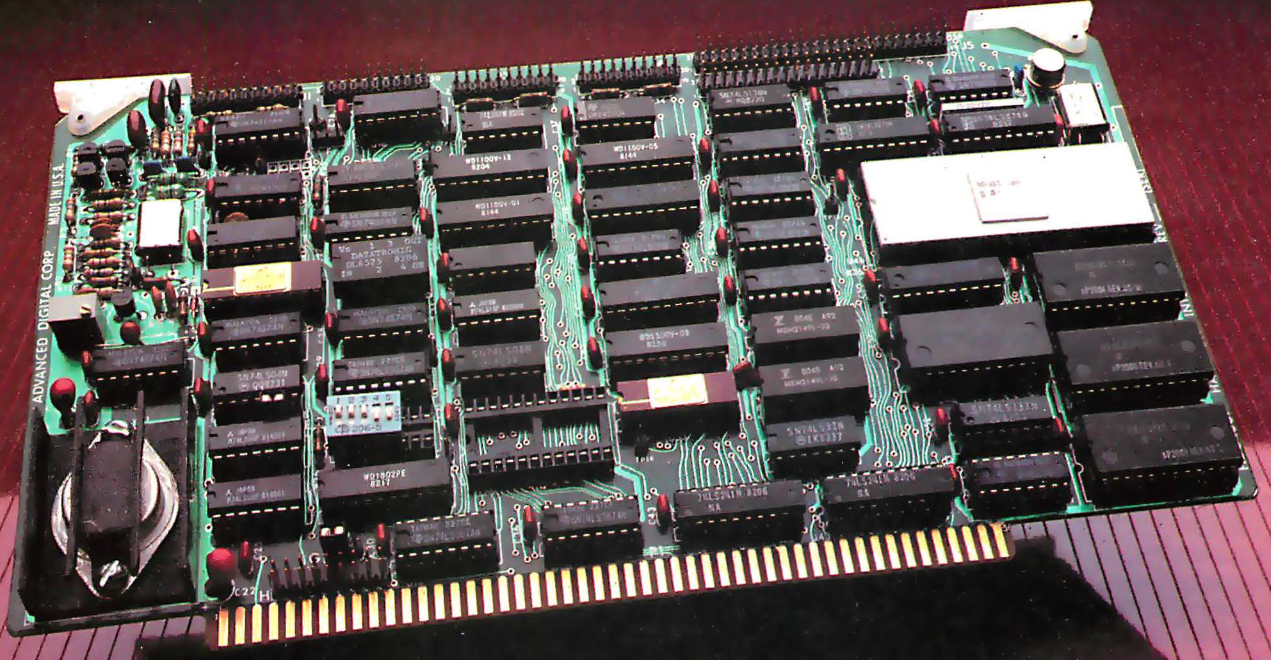
The third counter/timer circuit of the 8253 PIT is intended for use as a real-time clock for either time-of-day or software-timing-delay applications. This clock is initialized at power-up by software, preset for a 10-ms (millisecond) period (100 Hz). This clock output drives the IR0 line of the master 8259A interrupt controller, IC35, and forms the highest-priority maskable system interrupt. This timekeeping capability can be very useful in interrupt-driven, real-time process-control applications.

The fourth counter/timer on the MPX-16 system board is the timer section of the 8155H-2, IC47. This timer is driven by the SYSCLK2 (2.386-MHz) clock signal to produce the square-wave signal REFRQST, which has a period of 15.1 μs (microseconds). The REFRQST output signal activates the periodic refresh operation required by the dynamic RAMs (random-access read/write memories). This vital signal must never be altered by the user's application software; if it is, system crashes may occur.

Floppy-Disk Drive Controller

The MPX-16 system supports up to four floppy-disk drives. Versatility is provided by jumper-selectable features of the MPX-16's floppy-disk controller interface: either 5¼-inch or 8-inch drives may be used and up to four drives may be attached to the

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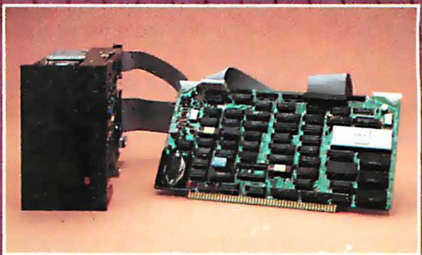
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All power to the disk drives is supplied from an external power supply through separate power cables. A typical 5¼-inch floppy-disk drive will require approximately +5 V (volts) DC at 0.5 A (amps) and +12 V DC at 1 A. A typical 8-inch drive will require +24 V DC at 1.3 A, +5 V DC at 0.8 A, −5 V DC at 0.05 A and 115 V AC at 0.3 A.

B. Output Lines

DRIVESEL *x*: The four drive-selection lines, numbered 0 through 3, are provided to enable the selected drive to respond to input signals and consequently to output data and/or status information. Each individual drive must be configured to respond to one of the four drive-select signals. This is usually accomplished via a programmable shunt header or a DIP switch. A drive is selected by a logic low state on the select line assigned to it.

DIRECTION: This control line defines the direction of motion of the selected drive's read/write head during a step operation. A high state (equivalent of logic 1) will cause the head to move out, toward the outer edge of the disk. A low state (logic 0) will cause the read/write head to move in, toward the center of the disk.

STEP: This control line causes the selected drive to move its read/write-head carriage one position in the direction controlled by the direction-select line. Each step is initiated by the low-to-high transition of the STEP pulse. Direction changes must occur at least 1 μs before the trailing edge of the step pulse.

WR ENABLE: The write-enable, or write-gate, signal enables the writing of data onto the disk when it is active-low. When this line is inactive-high, the read-data logic and head-step logic circuits are enabled.

HEADLOAD *x*: The four head-load lines, numbered 0 through 3, are alternative output lines which usually require the user to install or configure the drive unit to accept them. The head-load line can be used to load and unload the read/write head from the disk's surface. If desired, the heads may be kept loaded to avoid the 50-ms head-load time. Typically a drive will be configured so that the read/write head loads when either the drive-select line or the motor-on control line becomes active.

MOTOR ON *x*: Three output lines, numbered 0, 1, and 2, are provided for motor-on/motor-off control. The MOTOR ON 0 line on pin 16 of J11 and J12 is the standard floppy-disk interface signal. The MOTOR ON 1 and MOTOR ON 2 lines are available as alternative output control lines. When the MOTOR ON line of the floppy-disk drive (if available) is driven active-low, the drive motor will be turned on, allowing reading or writing on the drive. Typically, a 1-second delay is required after activating the motor control line prior to reading or writing. To maximize motor life, the motor for the drive is usually turned off after 2 seconds if no commands have been issued to the drive.

SIDESELECT: This output control line is used to select which side of a two-sided floppy disk is to be used for reading or writing. This line is provided for future system expansion; it is not supported by the current MPX-16 system software. A logic high on this line designates the read/write head on side 0, and a logic low indicates selection of the side-1 read/write head. A typical delay of 100 μs is required before reading or writing after switching sides.

LOW CURRENT: This output control line is an active-low signal used only by 8-inch drives. It causes a reduced current flow through the read/write head when writing data on tracks 43 to 76. When tracks 0 through 42 are selected, the low-current signal is high, causing a greater current flow.

FAULT RESET: This is an active-low output signal which can be used to reset a disk drive's fault logic, if the drive has some.

WR DATA: The write-data output line contains the serial data information to be written onto the disk. This signal is enabled by the WR ENABLE control line. Each positive transition on the WR DATA line causes the current through the read/write head to be reversed, thus writing a data bit onto the disk.

C. Input Lines

READY: The active-low READY input line can be used to indicate the status of the disk drives when the circuitry in the drive supports such a function. This signal typically indicates that the drive motor is rotating at the correct speed and that two index holes have been detected after a disk has been inserted into the drive. If drive-ready indication is not supported by the drive being used, the jumper to ground must be installed. The READY signal is conditioned by a 150-ohm pull-up resistor and a Schmitt-trigger inverter.

INDEX: The INDEX interface line is an active-low signal that occurs once for each revolution of the disk. This signal indicates the logical beginning of a track. It is conditioned by a 150-ohm resistor and a Schmitt-trigger inverter.

TRACK0: This input line is active-low when the drive's read/write head is positioned over track 0 of the disk (the outermost track) and the access logic circuitry is driving current through phase 1 of the stepper motor's windings. This signal is at a logic 1 at all other times. The TRACK0 signal is conditioned by a 150-ohm pull-up resistor and a Schmitt-trigger inverting buffer.

TWOSIDED: The active-low TWOSIDED input signal, for 8-inch drives, indicates that a double-sided disk is contained in the drive when low, and a single-sided disk is in the drive when high. This signal is terminated by a 150-ohm pull-up resistor and a Schmitt-trigger inverting buffer. This signal is not supported by the current system software but is available for future use as two-sided drives become more widely used.

WRITE PROTECT: This active-low input signal indicates that the disk inserted on the selected drive has been write-protected, and thus no write operations can be performed. On 8-inch drives, the write-protect notch is left uncovered to write-protect the disk; conversely for 5¼-inch drives, the write-protect notch on the disk must be covered to write-protect the disk. This input line is terminated by a 150-ohm pull-up resistor and a Schmitt-trigger inverting buffer.

FAULT: When available, on 8-inch drives, this input line indicates that a fault condition has been detected by the drive-control logic and that further operations on the drive should not be permitted. Thus active-low input is terminated by a 150-ohm pull-up resistor and a Schmitt-trigger inverting buffer.

RD DATA: The read-data input signal contains serial data and clock-bit information read from the disk when the WR ENABLE control line is high (inactive). This line provides an active-low pulse of approximately 200 ns for each flux reversal detected by the drive electronics, whether a data bit or a clock bit. This raw data signal is conditioned by a 150-ohm pull-up resistor and a Schmitt-trigger inverter.

Table 2: *Descriptions of the floppy-disk-drive interface signals found in the MPX-16 system. Both 8-inch and 5¼-inch drives are supported by the floppy-disk controller.*

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system. Three drive-motor-control lines and four head-load-control lines are available; both 34-pin and 50-pin connectors, with industry-standard signal/pin assignments, are provided for 5¼-inch and 8-inch drives, respectively. A description of the functions of each interface signal is given in table 2 on page 66.

Either single- or double-density recording may be selected under software control. The normal disk format is compatible with the IBM 3740 format (in the 8-inch size) or with the IBM Personal Computer (in the 5¼-inch size—what might be called the IBM 5150 format), but this can be changed via a software modification. Single-density recording uses the FM (frequency modulation) technique, while double-density operation uses the MFM (modified frequency modulation) technique. (See reference 7 for an explanation of FM and MFM as applied to floppy disks.)

The heart of the floppy-disk interface is an Intel 8272 single-chip floppy-disk controller, or FDC (IC21). This device appears in section 5 of the schematic diagram, figure 2 on pages 70 and 71, along with the rest of the floppy-disk interface logic.

The Intel 8272 was designed to be pin- and function-compatible with the NEC (Nippon Electric Company) µPD765 floppy-disk controller. These controllers support 15 software commands, processor-interrupt generation, DMA (direct memory access) data transfers, and generation of several control signals that can be used to reduce the amount of hardware support logic required to employ double-density recording formats. The 8272 FDC, in conjunction with the 8237A DMA controller, IC48, forms an efficient disk-interface subsystem.

There are six basic functional sections in the disk interface: clock-signal-generation logic, motor-on/off logic, drive-control logic, data-write logic, processor-interface logic, and data-recovery logic for reading the disk.

Clock-Signal Generation

The 8272 FDC requires two external clock signals as input: a 4- or 8-MHz square-wave clock and a data-write clock, with a pulse duration of 250 ns (nanoseconds), that is pulsed at one of three frequencies.

The square-wave clock input at pin 19 of the FDC is derived from an 8-MHz crystal oscillator, IC10. If 8-inch drives are to be used, jumper JP16 must be installed and JP17 removed. This routes the 8-MHz clock directly to pin 19. When 5¼-inch drives are to be used, JP27 must be installed and JP16 removed, applying a 4-MHz signal to pin 19, instead.

The repetition rate of the 250-ns data-write clock pulse is 1 MHz, 500 kHz (kilohertz), or 250 kHz, depending on the disk-drive type and disk format. Multiplexer IC3 selects the correct clock frequency for the desired recording density. When the MFM signal coming from the 8272 is in a logic low state, single-density frequencies are selected. When MFM is high, the double-density frequencies are selected.

Text continued on page 72

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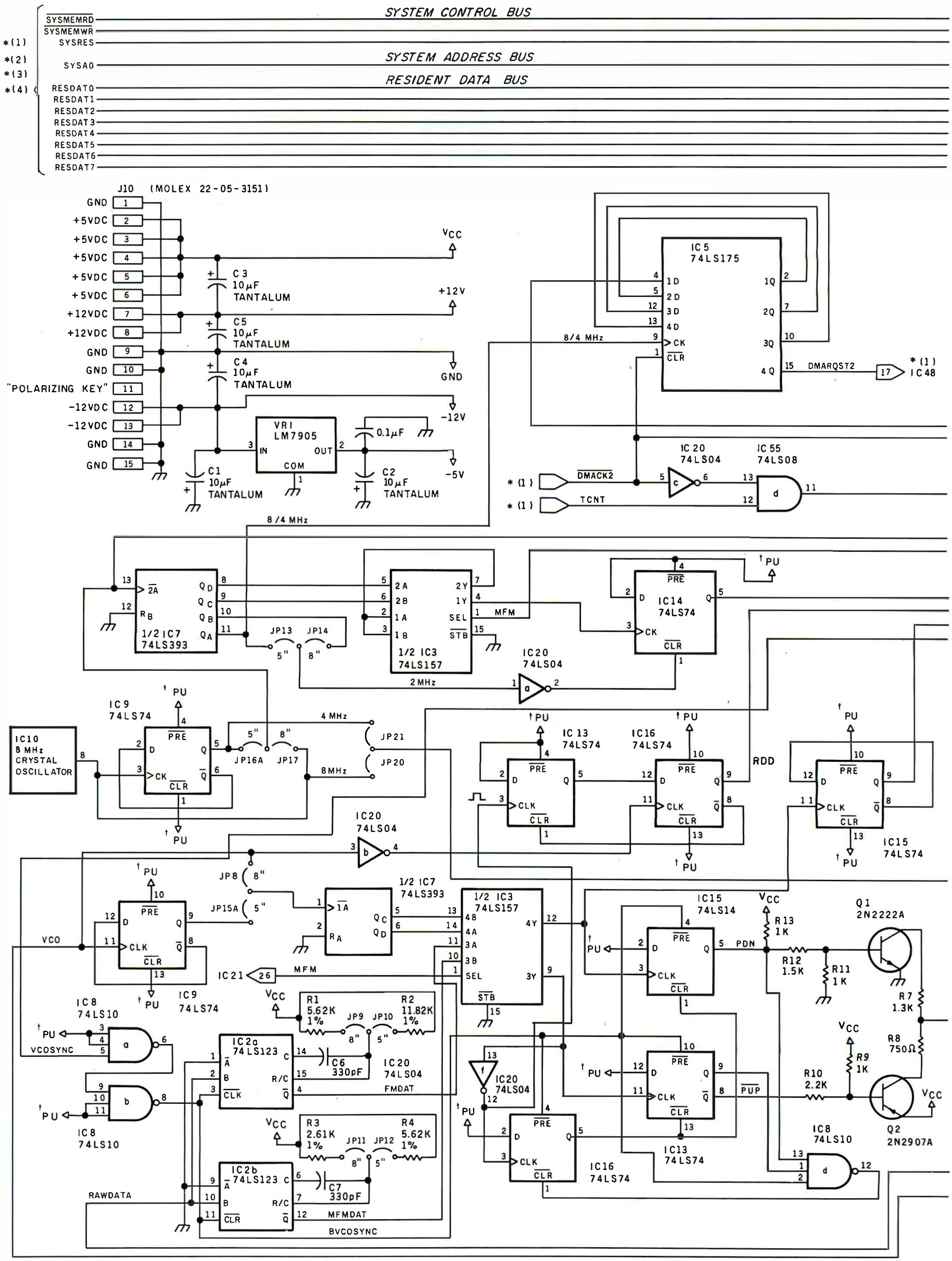
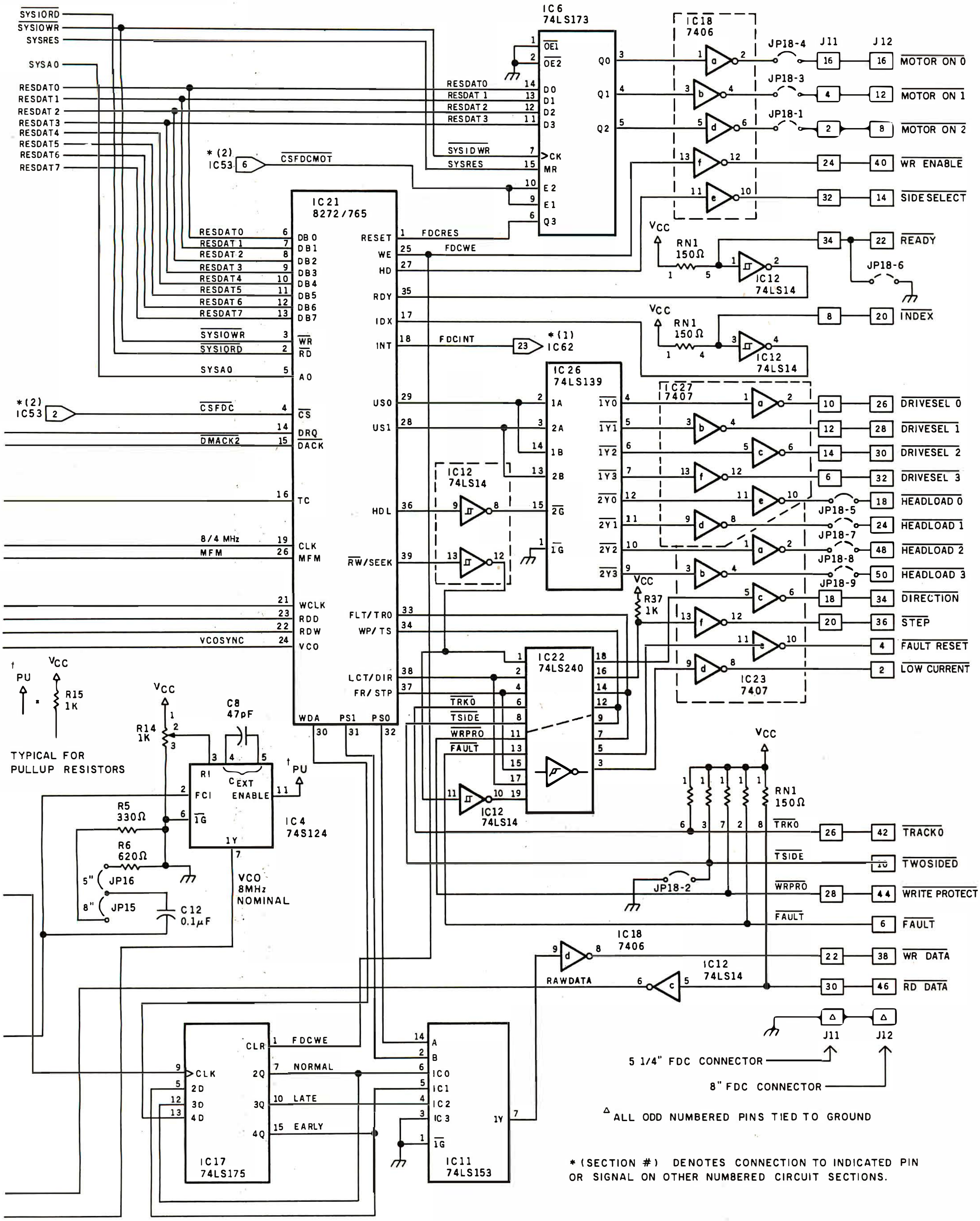


Figure 2: *Section 5 of the MPX-16 schematic diagram. Here are shown the system-board power connections and the floppy-disk controller, including the PLL (phase-locked loop) circuitry used to recover data read from a disk. Connections for both 8-inch and 5¼-inch drives are shown.*



A complete table of the MPX-16's integrated circuits was printed in the part 2 of this series (December 1982 BYTE, pages 56 and 60). The table included a listing of power connections and a cross-reference by schematic section.

Motor Control

The floppy-disk-drive interface provides three separate motor-on/off control lines for the floppy-disk drives: MOTOR ON 0, MOTOR ON 1, and MOTOR ON 2. These signals are generated by a 74LS173 quad D-type register chip, IC6. The 4-flip-flop register is addressed as an I/O device residing on the resident data bus at hexadecimal address 0A0.

The Q0 output of IC6 controls the MOTOR ON 0 line. To turn the motor on, a logic 1 is written into Q0, and to turn off the motor a logic 0 is written. The Q1 and Q2 outputs of IC6 similarly control the MOTOR ON 1 and MOTOR ON 2 lines.

The MOTOR ON 0 line is connected to pin 16 on both J11 (the 5¼-inch-drive connector) and J12 (the 8-inch-drive connector). Use of this pin for motor control in floppy-disk interfaces is fairly standard throughout the computer industry. The other two motor-control lines are not standard but are provided to allow additional control, if needed, by wiring the interface cable appropriately. The most common arrangement is for MOTOR ON 0 to control drive A, MOTOR ON 1 to control drive B, and MOTOR ON 2 to control drives C and D. All three control lines have an onboard jumper that can be used to disconnect the signal from the disk-drive connectors.

Drive-Control Logic

The floppy-disk-interface drive-control logic consists of all control signals other than the motor-on/off control signals supplied to or received from the electronic circuitry inside the floppy-disk drives. All of the output signal lines are driven by type-7406 open-collector inverting drivers or type-7407 open-collector noninverting drivers. All input signal lines are conditioned by 150-ohm pull-up resistors and 74LS14 Schmitt-trigger inverter gates. All of the signals, input and output, are active-low.

The RW/SEEK line of the 8272 FDC is used to multiplex eight DC interface signals onto four pins of the 8272. When the FDC is in the seek mode (with RW/SEEK low), pin 19 of the 74LS240 octal inverting buffer IC22 is driven low. This causes the TRACK0 and the TWOSIDED signals to be input into pins 33 and 34 of the FDC, and the DIRECTION and STEP signals from pins 38 and 37 to be output to the drives.

When the FDC is in the read/write mode (with RW/SEEK high), pin 1 of the inverting buffer IC22 is driven low. This allows the WRITE PROTECT and FAULT signals to pass into pins 34 and 33 of the FDC and lets the FAULT RESET and LOW CURRENT signals from pins 37 and 38 of the FDC pass to the drive. Note that the four signals that were gated by a low state on the RW/SEEK line are now blocked by the high-impedance state of their buffer sections. A pull-up resistor is provided to ensure that a false STEP command is not issued to the drive units.

The 8272 FDC provides two control signals to select one of four drives, US0 and US1 on pins 29 and 28. These two lines drive the 74LS139 dual 2-to-4-line demultiplexer, IC26, which selects the desired drive by placing a low state on the corresponding DRIVESEL *x* line. The signals from US0 and US1 are tapped off to another section of the demultiplexer to activate the head-load signal at the same time. (The interface may be wired to load all heads together or separately.)

The HD (head-select) output of the 8272, pin 27, is available for applications where two-sided disk drives are available. This signal can be used to select one of the two read/write heads. Initially, the MPX-16 system software supports only single-sided drives and does not use this control signal. A two-sided modification will eventually be incorporated.

Two input pins, the READY and INDEX signals are conditioned by 74LS14 Schmitt-trigger inverters and routed directly to the 8272. The READY line can be jumpered to ground if the attached drives do not provide a status-ready indication. An index pulse occurs once per revolu-

tion of the disk when a soft-sectored floppy disk (the type supported by the MPX-16) is being used in the selected drive.

Data-Write Logic

The data-write logic consists of the 74LS175 quad type-D flip-flop IC17 and the 74LS153 4-to-1 decoder, IC11. The 74LS175 is configured as a shift register clocked by the single/double-density write clock, which provides the precompensation required for double-density recording. The actual value (250 or 125 ns) depends on the particular drive size being used and is selected by jumpers JP20 and JP21.

Data-Recovery Logic

The data-recovery (data-read) logic of the floppy-disk interface, shown on page 70 of figure 2, is fairly complex, due to the subtleties of MFM double-density recording. The MPX-16 uses a PLL (phase-locked-loop) circuit to decode the double-density data. The 8272 floppy-disk controller, IC21, requires two input signals, the RDD and RDW signals at pins 23 and 22, respectively, to be generated from the raw-data signal read from the disk and transmitted to the interface by the drive electronics. The RDD signal consists of one positive pulse for each magnetic-flux reversal read from the disk, which can signify either a clock bit or a data bit. The RDW signal tells the 8272 of the status of the "data window" (a period of time in which a pulse may or may not occur), which is used by the 8272 to determine if the flux reversal is a data bit or a clock bit (see reference 7).

The 8272 provides two output signals, the VCOSYNC and MFM signals, that simplify the implementation of a PLL data-recovery circuit. The VCOSYNC signal goes active-high when valid data is being read from the disk and is used to enable the PLL logic. When a gap area (a place on a floppy disk where no data is recorded—for example, between the disk's identification and data fields) is being read by the read/write head, the VCOSYNC signal goes low to disable the PLL. In addition, the VCOSYNC signal can be high only after the read/write head has been loaded and the head-load time has elapsed. The MFM signal from the 8272, when active-high, indicates that the 8272 has been programmed for double-density operation; when MFM is inactive-low, single-density operation is indicated. This signal, along with the data-recovery logic, allows the recording mode to be software-selected between single- and double-density operation.

The active-high RAWDATA pulses from the disk-drive circuitry trigger two one-shot multivibrator sections, both in IC2, which serve as pulse shapers for the phase-detector logic. Section IC2a shapes the single-density (FM) data pulses, while section IC2b works for double-density (MFM) data. Separate one-shots are provided for the MFM and FM modes so that the recording format can be selected only by software.

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The one-shots take the raw data pulses from the drive and stretch or shrink them to a constant length, as required. The duration of the output pulses of the one-shots is determined by resistors R1 through R4 and capacitors C6 and C7. Jumper connections JP9 through JP12 are used to set up the correct pulse duration for 5¼-inch or 8-inch drives. The RC (resistance/capacitance) values are chosen to provide a shaped data pulse width that is one-half the duration of the data window. These values are 2 μs for 5¼-inch and 1 μs for 8-inch FMDAT (single-density data) pulses, and 1 μs and 500 ns for 5¼-inch and 8-inch MFMDAT (double-density data) pulses, respectively.

A type-74S124 voltage-controlled oscillator (VCO), IC4, generates a free-running 8-MHz VCO output frequency used to track the incoming data stream. The VCO frequency is also divided by 2 to produce a 4-MHz clock pulse. Jumpers JP8 and JP15 select the correct VCO frequency for the type of drive in use (8 MHz for 8-inch and 4 MHz for 5¼-inch).

The read-data pulse for the 8272's RDD input is derived from IC13 and IC16. Pin 5 of IC13 (the Q output) goes high when this flip-flop detects the rising edge of each inverted data pulse, which corresponds to the leading edge of the negative-going raw data pulse from the disk drive. On the rising edge of the next inverted 8-MHz VCO-clock pulse, the Q output of IC13 is then clocked into flip-flop IC16, forming the positive RDD pulse required by the 8272.

CP/M-86 BIOS

Digital Research's CP/M-86 operating system is designed to operate in almost any 8086- or 8088-based microcomputer system. This flexibility has been made possible by dividing the operating-system code into functional sections, one of which is accessible to the computer's manufacturer, dealers, and users. This section is the lowest-level portion and is called the *basic input/output system* or BIOS (usually pronounced "by-ahs" or "by-ohs" for short).

The higher-level BDOS (basic disk operating system—"bee-dahs"), the nucleus of CP/M-86, calls on the BIOS to gain access to the physical hardware of the computer system, in our case, the MPX-16. This provides a very machine-independent environment for the BDOS.

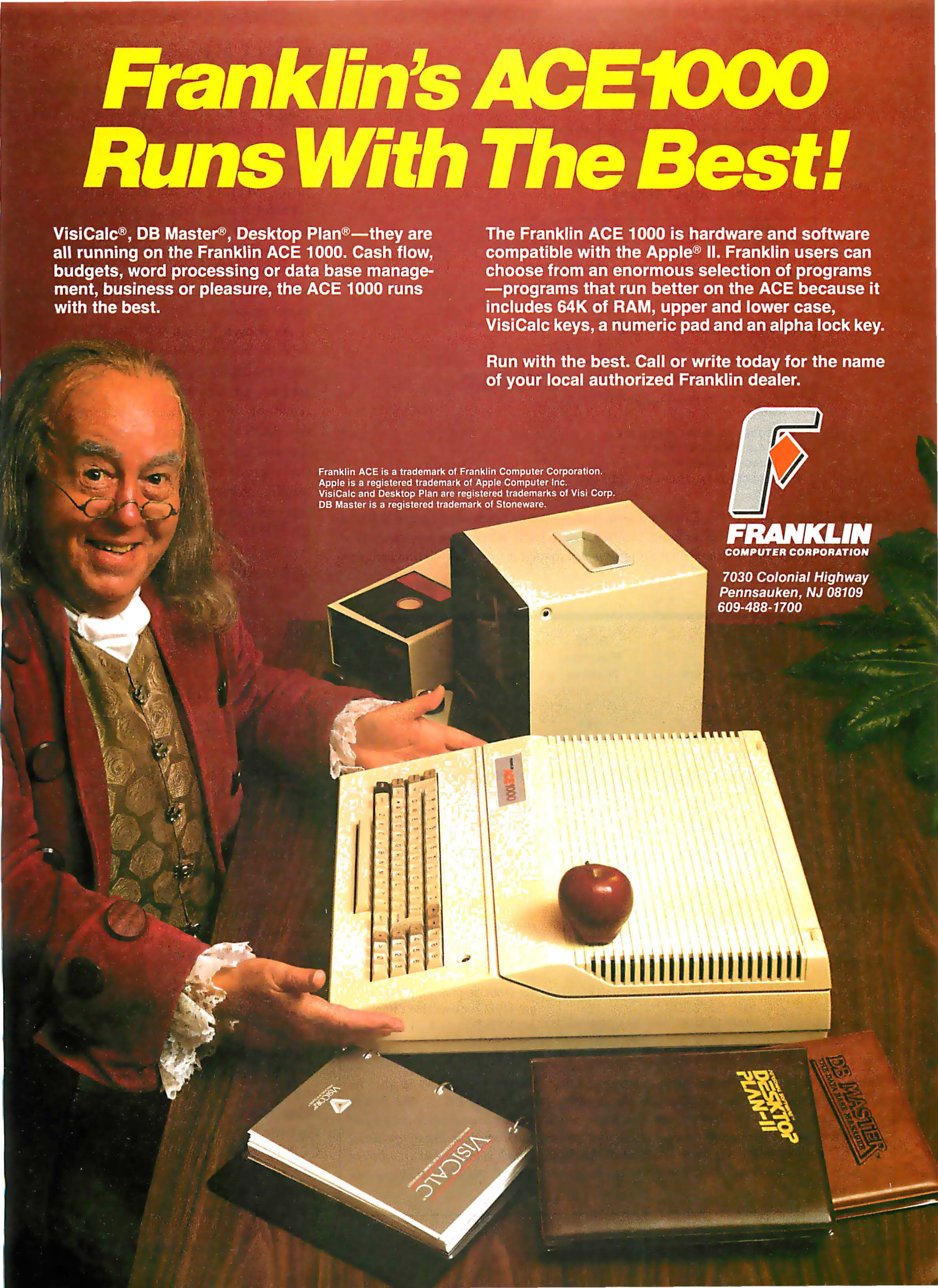
Imagine the BIOS as a slave that the BDOS can order around. The BDOS knows what it wants to do (communicate with the disk controller or console serial port, for example) but doesn't know exactly how to talk to the hardware. It does have rapport with the BIOS, though, and can ask the BIOS to communicate with the hardware and return the results.

As a user, you will almost always receive your CP/M-86 computer system with a customized BIOS previously installed by your manufacturer or dealer. But if you buy CP/M-86 directly from Digital Research, it will not contain a BIOS that will work with the MPX-16. To support this project, I have arranged for a customized BIOS to be written, burned into EPROMs, and distributed by The Micromint for use with the MPX-16.

The inner workings of the BIOS and full instructions on how to customize it are too complex to deal with in this article and are covered in great detail in the CP/M-86 documentation, so rather than duplicate that material, I shall attempt to explain in English terms what the various parts of the BIOS do.

BIOS Organization

The BIOS portion of CP/M-86 resides constantly in user memory during normal system operation. When power is first applied to the MPX-16, the 8088 processor comes up executing instructions at the very top of memory, in the space assigned to EPROM in the MPX-16. The first instruction it encounters is an initialization vector that causes control to branch to the initialization routine. This routine first performs diagnostic operations to make sure that the system is working properly, then it copies the BIOS out of its storage locations in the EPROM into addresses low in memory. Control is then transferred to the cold-start vec-


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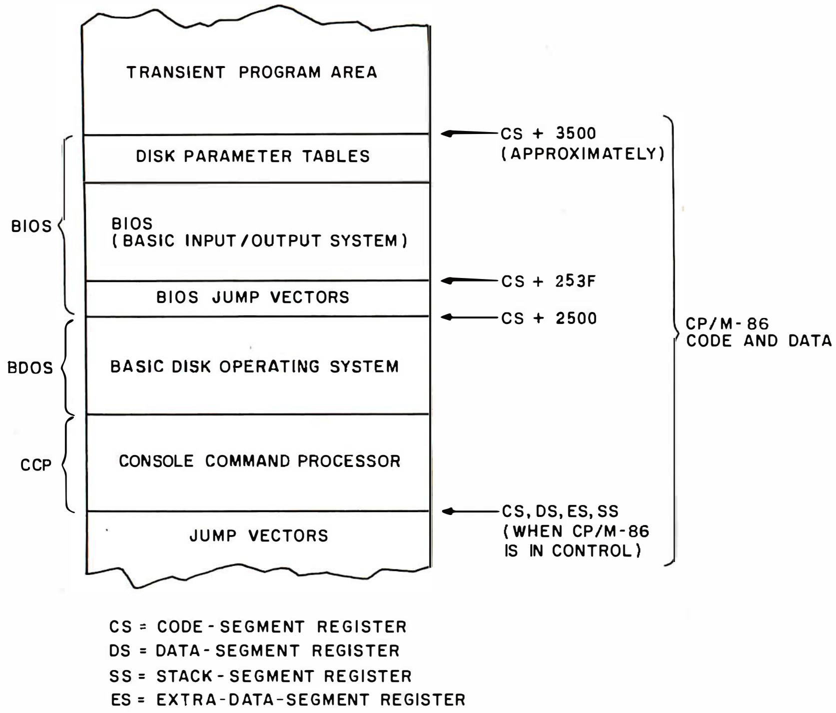


Figure 3: *Memory map of the CP/M-86 operating system as configured for the MPX-16. In 64K-byte systems, the CS, DS, SS, and ES registers will all contain a value of zero, and the segments will overlap. User programs are loaded into the TPA (transient program area).*

Offset from Start of BIOS	Instruction	BIOS Function Number	Description
0000	JMP INIT	0	cold start
0003	JMP WBOOT	1	warm start
0006	JMP CONST	2	console status check
0009	JMP CONIN	3	console character input
000C	JMP CONOUT	4	console character output
000F	JMP LIST	5	list-device character output
0012	JMP PUNC	6	punch-device character output
0016	JMP READER	7	reader-device character input
0018	JMP HOME	8	move to track 0
001B	JMP SELDSK	9	select a disk drive
001E	JMP SETTRK	10	set track number
0021	JMP SETSEC	11	set sector number
0024	JMP SETDMA	12	set DMA-offset address
0027	JMP READ	13	read selected disk sector
002A	JMP WRITE	14	write selected disk sector
002D	JMP LISTST	15	return list-device status
0030	JMP SECTRAN	16	sector translation
0033	JMP SETDMAB	17	set DMA segment address
0036	JMP GETSEGB	18	get MEM region table offset
0039	JMP GETIOB	19	get IOBYTE
003C	JMP SETIOB	20	set IOBYTE

Table 3: *BIOS (basic input/output system) jump vectors for CP/M-86 on the MPX-16. These jump instructions are the 21 entry points to the BIOS. The BDOS module calls these subroutines when it needs to send commands or receive data from the actual hardware (machine-dependent) interfaces, such as disk drives or serial ports. The offset address is from the start of the BIOS, which is located at an address in memory hexadecimal 2500 locations up from the start of the CCP/BDOS code segment.*

tor of CP/M-86, and normal operation begins.

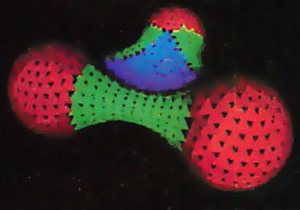
Figure 3 shows a typical memory map for a CP/M-86 installation. The BIOS is made up of several subsections. The first 63 bytes contain 21 jump vectors, each 3 bytes long. Each jump vector is an instruction to transfer control to the address in memory of a routine that performs an assigned low-level function, such as restarting CP/M-86 or getting a console character. These functions are listed in table 3.

As shown in figure 3, the BIOS resides in memory at an address offset by hexadecimal 2500 from the base address of CP/M-86. This offset is constant, but the upper boundary of the BIOS may change, depending on the size and special requirements of the microcomputer hardware. For example, some disk controllers are interrupt-driven, some are set up to use DMA transfers, and some use regular I/O transfers to communicate with the processor. The complexity of the BIOS depends on how many different features like these it must support.

The first two jump vectors, as shown in table 3, are for system reinitialization. The first one is called directly by the CP/M-86 loader program and performs any needed hardware initialization when CP/M-86 is loaded "from cold start" (for the first time after the computer is turned on). The second is called the "warm-start" vector because it is called whenever a program terminates (through BDOS function 0). After the warm-start operation has been completed, control is immediately transferred to the part of CP/M-86 with which the user converses, the console command processor, or CCP.

The next six jump vectors in table 3 transfer control to various character-I/O routines. In all of the routines, a character being sent out to a device must be placed in the CL register, and any character or status information being returned will appear in the AL register. For example, CONST, CONN, and CONOUT pass characters to and from the logical console device in this manner. The next vector (LIST) sends a character to the

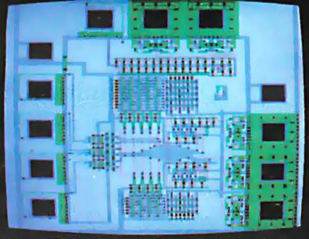
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logical list device (usually the printer). Further down, we see that function 15 (LISTST) returns the status of the list device.

The reason why the list-status routine is not located adjacent in memory to the list-output routine is simple: when the first version of CP/M-80 was written, no list-status routine existed. It was added later, but to avoid rearranging all the jump vectors, it was added as function 15. In CP/M-86, other jump vectors were added after it. The logical device names Reader and Punch are actually obsolete. They were intended for a paper-tape reader and punch, but these routines are now used to operate various auxiliary input and output devices.

Disk I/O Routines

BIOS functions 8 through 14 and function 16 are used for disk-controller communications. For example, the HOME function causes the currently selected disk to return to track 0 (that is, it causes the read/write head to seek to the outermost track). The SELDSK function activates the disk drive whose address is passed in the CL register and makes it the current disk (this is how the default disk is activated).

The READ and WRITE functions transfer a single record (128 bytes) from the current DMA buffer (set with SETDMA) to or from the currently selected disk (SELDSK) at the current track and sector (SETTRK and SETSEC). The BDOS refers to the disk directory on disk to know where to read or write information when needed.

Disk-Definition Tables

All of the recently introduced operating systems from Digital Research, including CP/M-86 and CP/M-80 version 2.2, are table-driven. This means that all the disk definitions and storage-allocation information is kept in tables in the section of memory occupied by the BIOS, rather than in the BDOS. This allows for flexibility in interfacing disk drives and other peripheral devices to the system. Early versions of CP/M-80 assumed that all disks attached to the system were identical: 8-inch single-density drives. Now, many systems have one to four floppy disks, and perhaps an additional hard disk, for mass storage. A few even have so-called RAM disks (large-capacity semiconductor random-access read/write memories set up to simulate disk drives). Because the modification of the tables is usually performed by an experienced programmer, the user rarely has the need to modify them. (To keep this article from running overlong, I'll let those of you who are really interested look to the CP/M-86 documentation to learn those software mysteries.)

In Conclusion

That's all the information on the MPX-16 we can reasonably cover in three magazine articles, but more information is available for those of you who need it in the *MPX-16 Technical Reference and User's Manual*, available separately from The Micromint.

You've probably noticed a great reliance on Intel components throughout the computer. These are present in the MPX-16 for compatibility, because they are used in the IBM Personal Computer, but I suspect that IBM's design team selected these components because of Intel's foresight in promptly supporting its 16-bit microprocessors with parts that work well together, at reasonable cost, in a complete solution to a computer-design problem.

Overseeing the design of the MPX-16 has been quite an adventure for me these past few months. I hope you've enjoyed reading this epic.

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To receive a complete list of Ciarcia's Circuit Cellar project kits available from the Micromint, circle 100 on the reader service inquiry card at the back of the magazine.

Editor's Note: *Steve often refers to previous Circuit Cellar articles as reference material for each month's current article. Most of these past articles are available in reprint books from BYTE Books, McGraw-Hill Book Company, POB 400, Hightstown, NJ 08520.*

Ciarcia's Circuit Cellar, Volume I, *covers articles that appeared in BYTE from September 1977 through November 1978.* Ciarcia's Circuit Cellar, Volume II, *contains articles from December 1978 through June 1980.* Ciarcia's Circuit Cellar, Volume III, *contains the articles that were published from July 1980 through December 1981.*

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* * *

When it becomes available for the MPX-16, Microsoft's MS-DOS operating system may be optionally substituted for CP/M-86.

The MPX-16 is available to OEMs in large quantities. Various forms of kits and subassemblies will eventually be available. Call The Micromint for prices and delivery information. The Micromint will test previously wave-soldered circuit boards assembled by users for a fee of $50.

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Heath's HERO-1 Robot

Steven Leininger
Leininger and Associates
5402 Summit Ridge Trail
Arlington, TX 76017

Heath, a leading supplier of educational electronic kits, began a few years ago to design an industrial electronics course. Intending to teach the broad range of skills necessary for electromechanical control and real-world interfacing, the instructors wanted a hardware training kit that would demonstrate stepper-motor control, sound input and output, and object detection and ranging.

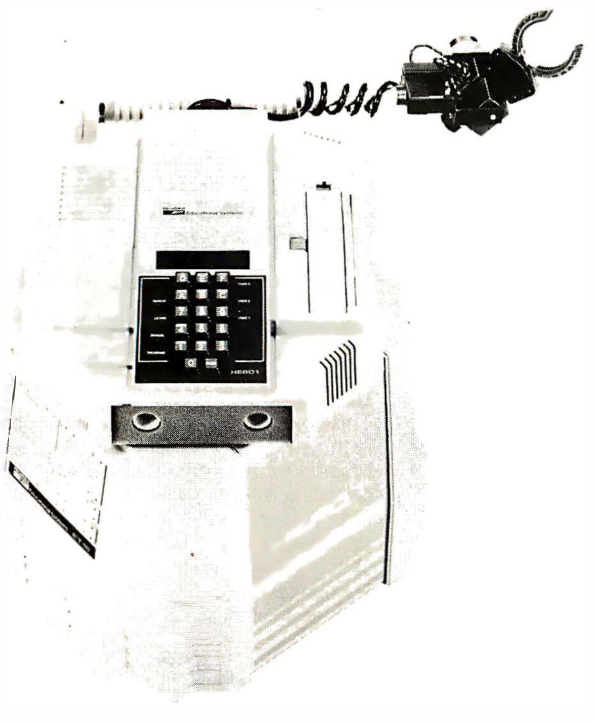


Photo 1: *The assembled Heath HERO-1 robot.*

One proposed kit had all of the actuators and sensors mounted on a breadboard chassis plus a book detailing the experiments that could be performed. That was the way Heath instructors had taught computer technology with their classic microprocessor trainer. But they decided to go beyond the microprocessor-trainer concept and build an educational device that would be fun to use after the experiments were over. A robot seemed to be the ideal solution.

The engineers at Heath approached the robot project with great enthusiasm. Imagine having the charter to design a robot that demonstrates virtually all principles of automation and robotics. The final product of this engineering effort is now available as HERO-1 (Heath Educational Robot-1).

The Mobile Robot, Circa 1982

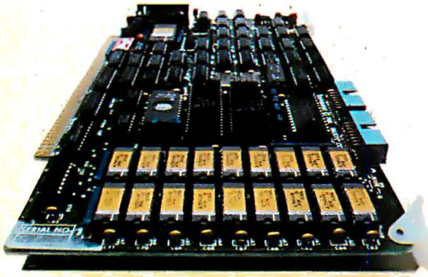
The HERO-1, completed and "fully clothed" (see photo 1), looks like a distant cousin of R2D2. It stands about 20 inches high on its three-wheel base and weighs 39 pounds. Though HERO-1 is not as strong, fast, or accurate as its industrial counterparts, it does have an impressive list of capabilities. It can sense sound, light, motion, distance, and time; it can move about the room and grasp objects with its optional programmable arm. It can even do a credible job of speaking with its optional speech synthesizer.

The robot is controlled by an onboard computer that can be programmed manually via the hexadecimal keypad on top of the head assembly. Each function of the HERO can be exercised with just a few lines of code to verify correct operation or to demonstrate one or more principles of industrial automation. After the low-level functions of the robot are understood, the user can then get a taste of real-time robot programming with the

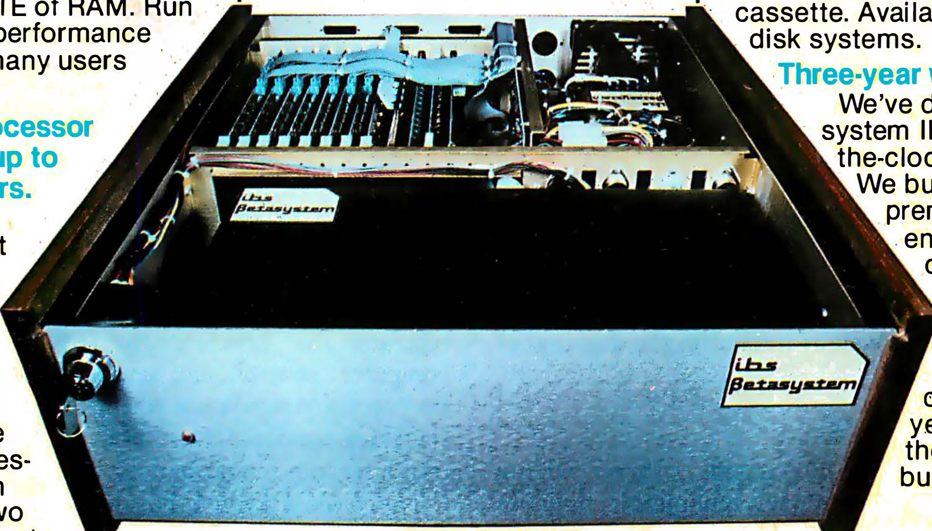
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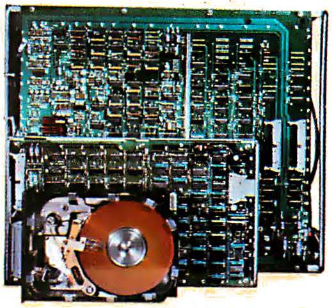
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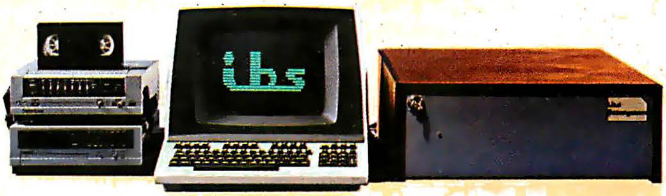
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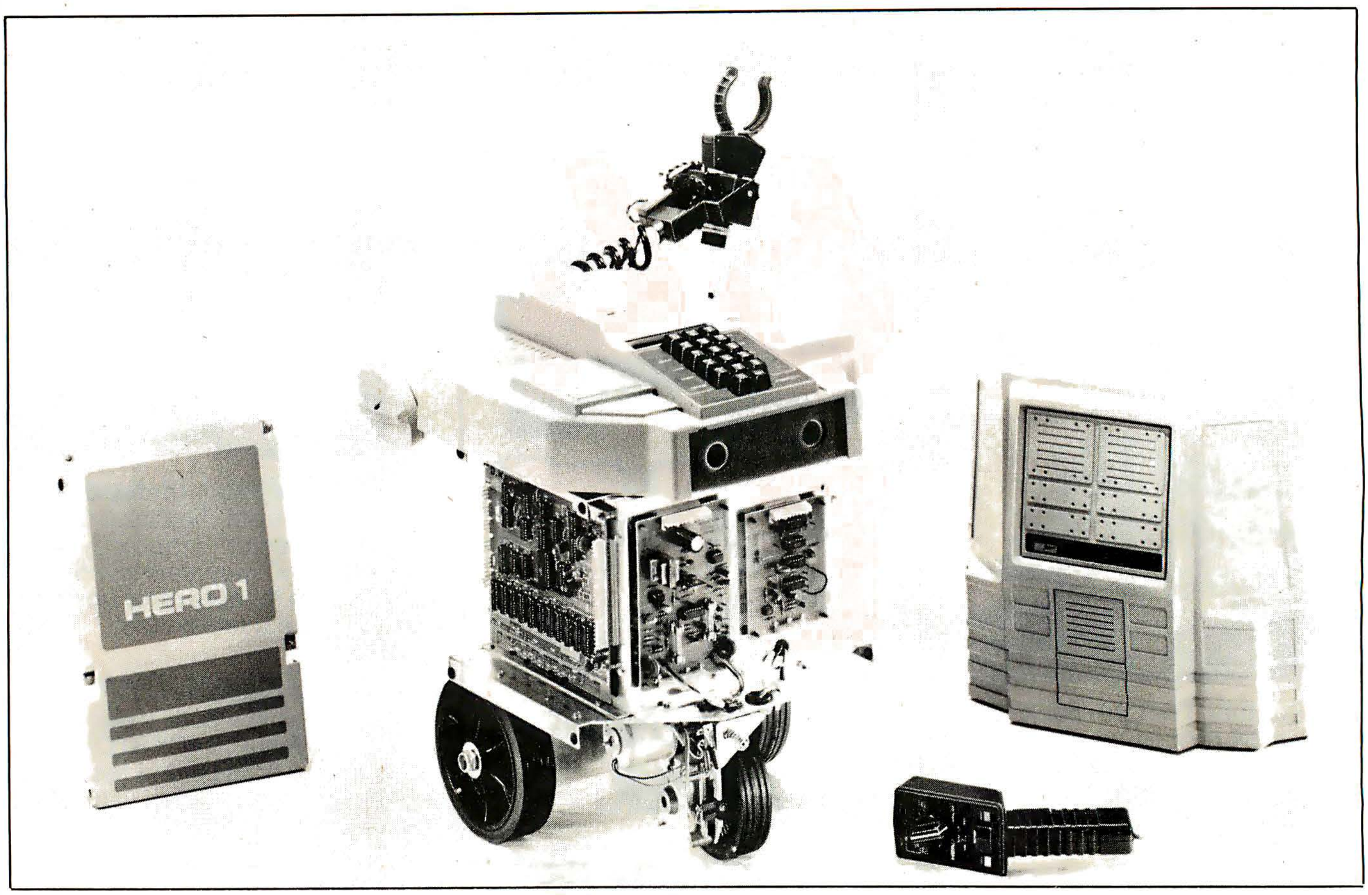


Photo 2: *The Heath HERO-1 robot from the assembler's perspective. Note the teaching pendant (remote control) and the variety of sensors in the robot's head.*

teaching pendant (see photo 2). The teaching pendant, basically a remote controller connected to the robot by wires, can be used to select the desired motion, such as forward motion at half speed or raising the arm to a horizontal position, as well as to control the duration of that motion.

Inside the HERO-1

Fourteen printed-circuit boards, three wiring harnesses, and four heavy-duty rechargeable batteries make up the bulk of the electronics. The main processor board comes from Heath already assembled and tested so that the student of robot technology does not have to be a computer-troubleshooting technician as well. The processor board has 4K bytes of programmable memory, 8K bytes of ROM (read-only memory), and a Motorola 6808 microprocessor. The ROM contains the machine-language debugger program that allows hexadecimal data to be loaded into the HERO-1 via the keyboard. It also contains the Robot Interpreter program, which simulates a possible ideal instruction set for the control of the motors, speech, and real-world interfacing.

Power for the HERO-1 comes from four gelled-electrolyte rechargeable batteries connected as two independent 12-volt (V) supplies. Enough power is available to run the robot for at least an hour of untethered operation. The robot can also operate continuously if connected to the battery charger included with the HERO-1, but of course mobility is impaired by the line cord.

An internal power-supply board contains a switching regulator that generates the required voltages for the computer, control, and sensory circuitry and provides the necessary regulation when recharging the batteries. A switching regulator was chosen because its high efficiency translates into longer battery life and cooler operation.

The basic HERO-1 has two stepper motors and a permanent-magnet DC motor. One stepper motor is used to rotate the head, so that sensors can be pointed in the desired direction independent of the body attitude. The other stepper motor is used to set the direction of the drive wheel with respect to the body for steering.

Heath chose a large DC motor as the main drive because of the torque required to move nearly 40 pounds of plastic, metal, and electronics. In order to provide some sort of feedback to the system about the distance traveled, an optical sensor was mounted on the front wheel with an encoder disk to send pulses to the computer for counting.

The HERO-1 senses distance with a pulsed ultrasonic SONAR (sound navigation/ranging) system operating at 35 kHz. An ultrasonic transmitter emits a pulse to be detected by an ultrasonic receiver. The time interval between the transmitted and received pulses is proportional

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to the distance to the object. The system has a resolution of 0.42 inches over a range of about 8 feet. This ranging feature is primarily useful for avoiding obstacles while moving about under program control.

The motion, sound, and light-detection circuits are interfaced to the onboard microprocessor with an 8-bit A/D (analog-to-digital) converter. This produces a binary digital number ranging from 0 to 255 in response to an input voltage from a sensor selected by the controller. The higher the voltage from the sensor, the higher the output value to the 6808 microprocessor.

Motion is detected by using a continuous-wave ultrasonic field like that used in an ultrasonic burglar alarm. The robot looks for a change in the amplitude of the reflected ultrasonic waves to indicate that something is moving in its field of coverage. Of course, the robot must remain stationary during motion detection so that it is not simply detecting its own motion.

Light can be detected and quantized with a light-dependent resistor connected to the robot's A/D converter. The robot can aim the light sensor by moving its head so that it can determine the direction of a light source by looking for the maximum intensity. (This way, the HERO-1 can surely find the light at the end of the tunnel.)

Sound is detected with a microphone connected to the A/D converter. While it is not capable of any sort of complex speech recognition, the properly programmed robot can listen for and count syllables to effect crude recognition. In other program applications, the ambient sound level may be important. Once again, the A/D converter provides an 8-bit representation of the sound level at any given instant, which can be processed as desired in the user's program.

The HERO-1 uses the Votrax SC-01 speech synthesizer integrated circuit as its "larynx." This device produces phonemes in response to digital inputs. These phonemes, which are the basic building blocks of intelligible speech, can be combined under program control to produce words, phrases, and sentences. The HERO-1 comes with several built-in phrases, such as "Warning! Warning! Intruder! I have summoned the police!," "Your wish is my command," and "Oh no! I do not do windows!" You can program your own phrases and sound effects into the robot via the keypad, so that the speech can be tailored to satisfy your special requirements.

An onboard calendar/clock counts seconds, minutes, hours, days of the week, days of the month, and months. You can use this in programs and experiments to delay the actual execution of an event until some future time (like having HERO-1 say "happy birthday" when you come within detector range on your birthday).

An experimenter's solderless breadboard, with connections to an I/O (input/output) port and interrupt line on the microprocessor board, is mounted on HERO-1's head. Ground signals and 5-V and 12-V power are supplied so that an external power supply is usually not required. Heath provided this breadboard to give the user a chance to perform experiments from Heath's Robotics Course and to encourage individual experimentation.

The optional manipulator arm has five more stepper motors and is attached to the head. The arm can pivot about its shoulder, extend and rotate the hand at the wrist in two independent directions, and actuate its claw.

At a Glance

Name
HERO-1 Robot

Manufacturer
Heath/Zenith Educational Systems
Department 150-145
Benton Harbor, MI 49022
(616) 982-3200

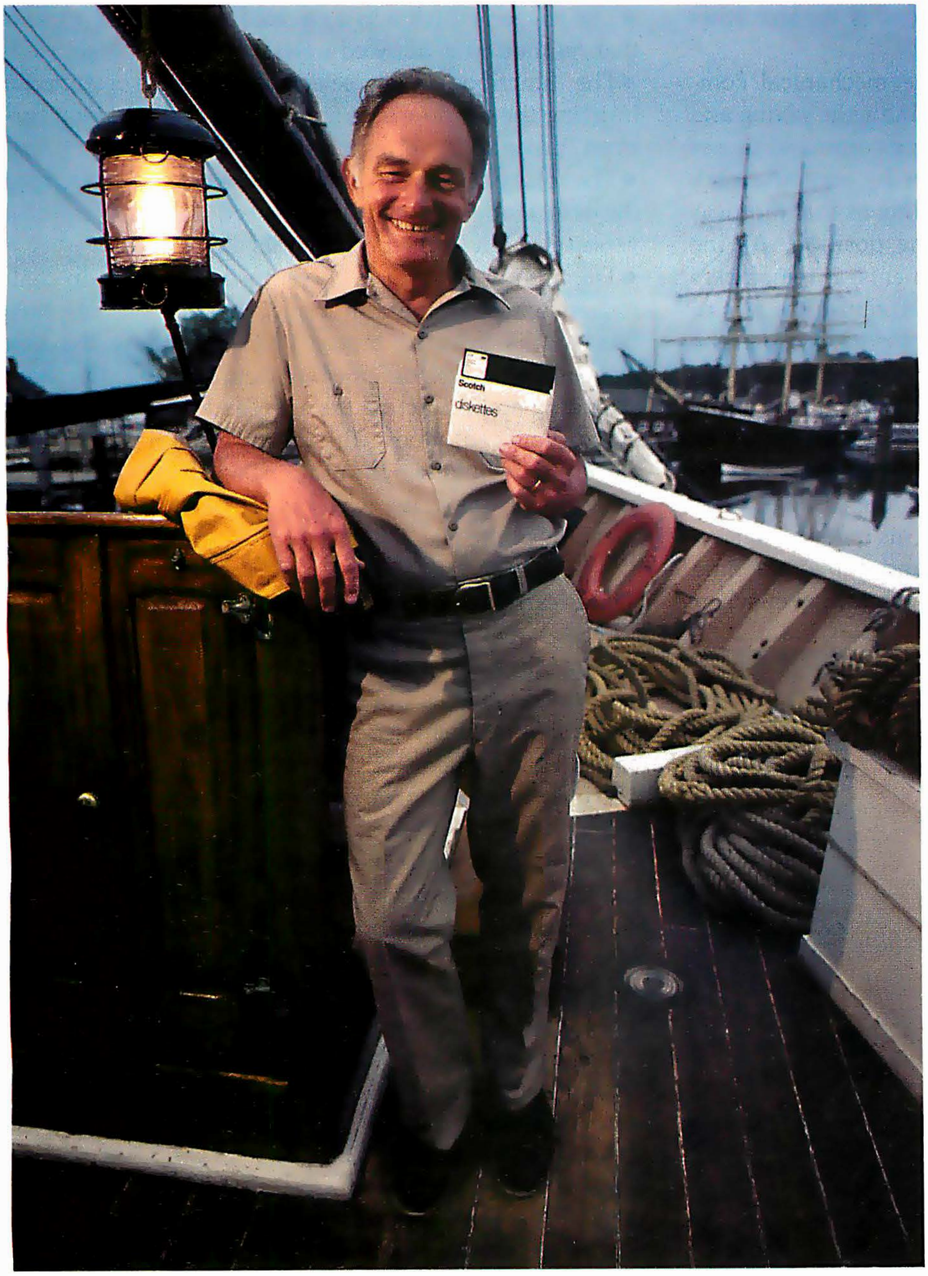
Price
Basic HERO-1 kit (ET-18), without the arm and speech synthesizer, $999.95; arm add-on kit, $399.95; speech add-on kit, $149.95; HERO-1 package including arm and speech synthesizer, $1495; training course, $99.95; assembled HERO-1 (ETW-18), $2495

Features
Size: maximum of 20 inches high by 18 inches wide (50 cm by 45 cm); 39 pounds (17.6 kg)
Sound detection: frequency range, 200 Hz to 5000 Hz; amplitude range, 256 discrete steps; directional characteristics, almost horizontally and vertically uniform
Light detection: frequency range, visible spectrum; amplitude range, 256 discrete steps; sensor beam angle, approximately 30 degrees
Ultrasonic ranging: pulsed ultrasonic, 35 kHz; range, 0 to 8 feet (0 to 2.4 meters); resolution, 0.42 inches (1 cm); sensor beam angle, approximately 30 degrees
Motion detection: continuous-wave ultrasonic field; range, can detect an adult at about 15 feet (5 meters); directional characteristics, horizontally and vertically uniform if pointed at wall
Time sensing: battery-powered clock IC: in units of seconds, minutes, days of week, days of month, months; accuracy, plus or minus 120 seconds per year
Mechanical: head, rotates 350 degrees in horizontal plane; shoulder, rotates 150 degrees in vertical plane; arm, extends 5 inches (12.7 cm); wrist, pivots 180 degrees, rotates 350 degrees; gripper capacity, 0 to 6 inches (0 to 15.2 cm); arm payload, horizontal and retracted, 16 ounces (450 grams); horizontal and extended, 8 ounces (225 grams); gripper force, 5 ounces (140 grams); minimum turning radius, 12 inches
Battery charger: power requirements, 120/240 V AC, 50/60 Hz, 60 watts maximum; output voltage, 27 V DC (maximum) unregulated; output current, 1.9 A (maximum) into fully discharged batteries; recharge time, 10 hours (maximum) with robot off
Batteries: four 4-amp-hour, 6-V gelled-electrolyte rechargeable cells
Speech (optional): phonemic speech IC; number of phonemes, 64; levels of inflection, 4

Documentation
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3M Hears You...

3M

Circle 403 on inquiry card.

This arm is not as fancy or as accurate as some stand-alone robot arms, but for $399.95, the HERO-1 arm assembly is an outstanding bargain that helps an experimenter become familiar with robot control.

Operation of the HERO-1 Robot

When power is first applied to the robot, it responds with the synthesized word "ready." HERO-1 is now in the executive mode and is ready to enter one of the five other modes.

The utility mode can initialize the mechanical components, set the internal clock, and handle the saving and loading of program data. The initialize command causes the robot to seek a known position by stepping each motor until a limit switch corresponding to that motor is tripped. HERO-1 is now in its home position. As the robot performs head and arm movements, it remembers just how far it has moved, so that it can return the arm to the home position via the shortest route when given the Home Arm command.

With the utility mode you can save programs on or load them from cassette tape. Lengthy experiments can be saved for further study, or application routines can be loaded after power-up, eliminating the drudgery of reentering previous work manually. This mode also has a command that allows the user to set and display the time and date in the clock/calendar. The clock runs even when the robot is turned off, so that the time is always accurate once it has been set.

The manual mode permits operation of HERO-1 with the teaching pendant, whose cable and connector attaches to the rear of the robot. Unfortunately the pendant allows only one function at a time, so the operator can't move the arm and drive at the same time. There are four switches on the teaching pendant:

- The trigger switch acts as a dead-man switch, meaning that no motion is allowed unless this switch is pressed.
- The function switch selects between arm functions (moving the head, arm, and gripper) and the body functions (drive and steering motor operations).
- The rotary selector switch is used for motor selection in the arm mode and combined speed and forward-or-reverse selection in the body mode.
- The motion switch is a three-position, return-to-center rocker switch. In the arm mode, it determines the direction of the selected motor, thus providing the complementary tasks of opening and closing the hand, extending and retracting the arm, and so on. In the body mode, you can choose the direction of travel with the motion switch. When the motion switch is released in the body mode, the drive wheel is returned to the straight-ahead position.

The learn mode is very similar to the manual mode, except that the commands from the pendant are entered into memory at the same time that the motions are being performed. You can then instruct the robot to repeat the previous movement sequence in its entirety or to move through the sequence a step at a time. You can even tell HERO-1 to reverse arm and head motions to undo what it did.

The program mode is entered from the executive mode and is a hexadecimal debugger/monitor program like those usually found on microprocessor training kits. With this mode the real die-hard hackers (computer experimenters) can enter machine-language code to be executed directly by the 6808 microprocessor.

The repeat mode is an improvement over the program mode because it provides access to the Robot Language, a robotics interpreter that supports motion control and sensor management as additions to the 6808 machine language. The interpreter runs 10 to 100 times slower than its pure machine-code equivalent, but the simplification of applications-program writing usually makes this compromise worthwhile.

Both the program and repeat modes help the user perform apparently simultaneous operations—such as arm motion, sensing, talking, and moving around—by alternating tasks so quickly that they appear to be happening at the same time.

Taking the HERO-1 for a Test Drive

On a visit to the Heath facilities in Benton Harbor, Michigan, I had a chance to evaluate (read that "play

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with") one of the preproduction prototypes of the HERO-1. When the robot was first initialized, it responded with a mechanical-sounding "ready." I picked up the teaching pendant, and everyone stood around confidently watching as I examined the controls.

I directed HERO-1 around the room and trapped it between some chairs . . . Going back to the arm mode, I reached for a coffee cup and picked it up.

Having recently completed my review of a robot arm (see "Colne Robotics Armdroid, The Small Systems Robot" in the May 1982 BYTE, page 286), I decided to test HERO-1's arm first. After some practice, I was able to zero in on a Styrofoam coffee cup and pick it up (hmm, not bad).

Of course, the microcomputer had stored all of my commands in its memory and could repeat those motions to duplicate my feat. When my commands were "played back," the robot waved its arm back and forth just as I had done while becoming familiar with the controls. The Heath engineers showed me how the sequences could be examined with the keyboard and display and how they could be edited to remove or adjust undesired sequences.

For the mobility test, I flipped the function switch on the pendant from "arm" to "body," selected the speed and direction, and pulled the trigger to make it go. Boy did people move fast! I almost drove one of only three HERO-1s off the conference-room table! The Heath people invited me to continue the trial run with the robot on the floor, (Ah, that's what I needed, running room!)

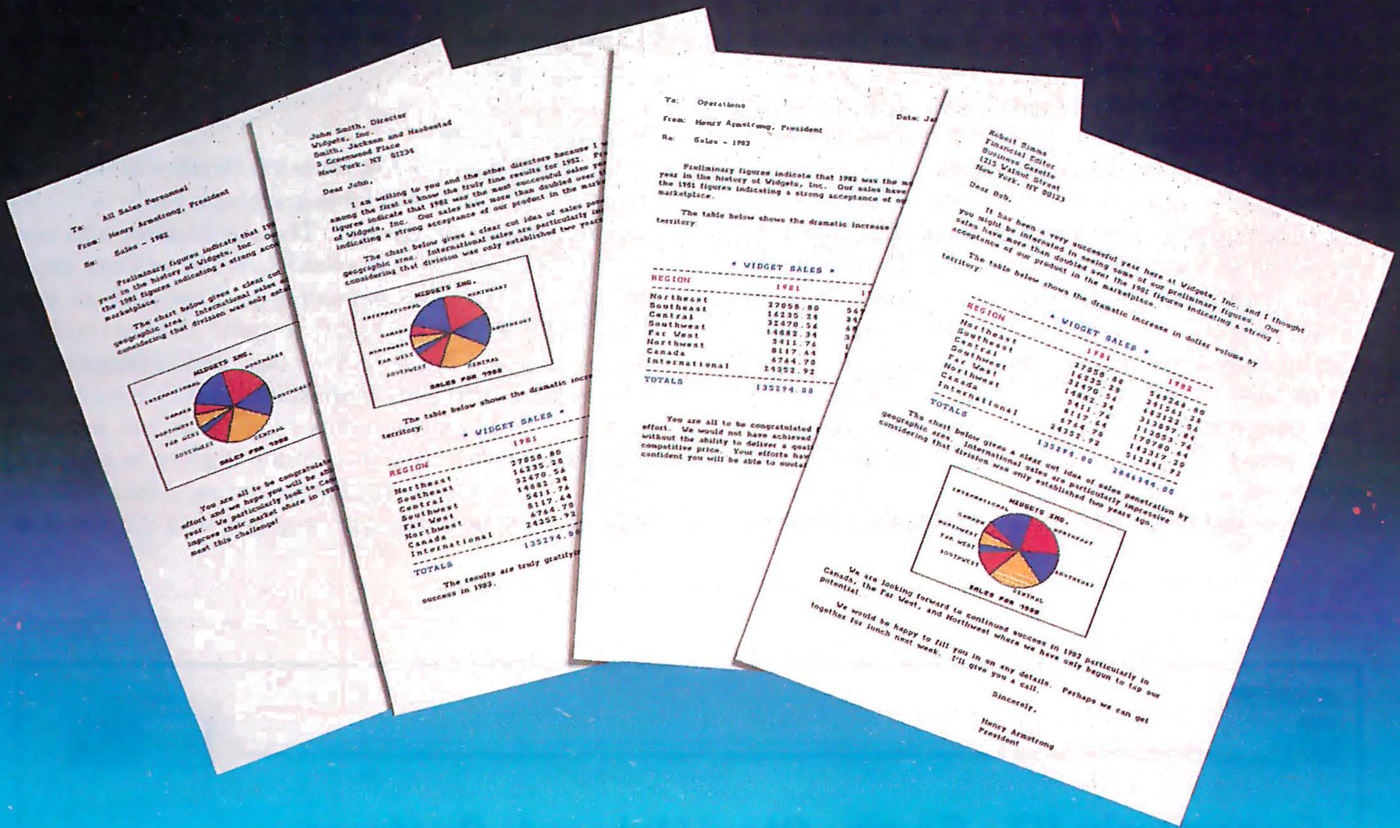
With the pendant in my hand, I directed HERO-1 around the conference room and trapped it between some chairs. A little change of direction and I backed it out of the dead end and steered for the table. Going back to the arm mode, I reached for another coffee cup and succeeded on the first attempt.

After evaluating HERO-1 for about an hour, I can truly say that it is a product of extraordinary flexibility and function. I've seen speech synthesizers before, worked with robotic manipulators, watched maze-solving, microprocessor-controlled "mice," and used microprocessor trainers and breadboarding systems, but I have never seen all of that in one package before!

The Written Word

HERO-1 comes with four manuals. At the time this review was being typed, only the user's manual was available for preview; but well-written manuals have always been a mark of the Heath company, and after exa-

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mining the user's manual, it looks as if the ones for this product will be no exception.

The user's manual is a basic overview of the robot's operation, a quick lesson in how to use HERO-1. This document gives the first-time user the information necessary to perform simple tasks with HERO-1. It explains the different modes of operation and gives some short sample programs that demonstrate the sensory and speech capabilities of the robot.

Heath will include the assembly manual with all HERO-1 kits. While there are a lot of printed-circuit boards to be assembled and tested, the task doesn't appear to be significantly different from that of building a color television set, so an assembly manual for HERO-1 should be a simple matter for Heath.

Heath will supply a technical manual to describe the function and use of the robot in detail. This will perhaps be the most challenging manual that Heath has undertaken. To adequately describe, in detail, all the subtleties of the sensory, motion, manipulative, and speech systems is truly a formidable task. I've been assured that a lot of time is going into making this a "heavy-duty, here's-everything-you-need-to-know" document.

A speech dictionary made up of the most common words will also be supplied to help users build their own sentences and phrases to use with the speech synthesizer.

A Training Course Too

Heath will be offering a robotics training course to supplement hands-on experience with the HERO-1. Students will learn the principles and fundamentals of industrial robotics. The course will cover robot terminology, types, and applications; motors and power sources; basic hydraulics and pneumatics; robot control and controllers; and sensors and real-world interfacing.

The course, to be available for $99.95 (excluding HERO-1, of course), covers a 1200-page manual and has experiments that you can perform on HERO-1 to demonstrate concepts.

The Bottom Line

If you are interested in robotics, Heath will show you the way. HERO-1 is available in kit form for $999.95, less arm and speech synthesizer. The manipulator arm costs another $399.95, and the speech synthesizer costs an additional $149.95. A combination package with all three costs $1495. If you don't want to spend 35 hours building the robot, plus 3 hours on the voice, and 10 hours on the arm, a fully assembled, ready-to-roll HERO-1 is available for $2495. Anticipating interest from hobbyists, industry, and educational institutions, Heath is going to support a HERO-1 users group so that programs, ideas, and applications can be presented, swapped, and supported. ■



That, of course, was the promise nearly all computer manufacturers made to us.

But along the way, the promise was unfulfilled.

People found out that even the simplest computer languages were as troublesome and time-consuming as high school French — fine if you like that sort of challenge, but a real barrier if what you want to do is *use* a computer, as opposed to *learning* to use a computer. A lot of people found they could live their whole lives without ever knowing what GOSUB, LOGIN, or MID$ meant.

The first anybody-can-use-it computer.

That, in a nutshell, is what makes the Epson QX-10 the most astonishing breakthrough in personal computer technology ever. Not only does it have some of the most advanced hardware available on the market today, it is a system that requires no computer classes, no study, no lectures, no books; a system you can *use*, right out of the box, backed by little more than logic, intuition and native intelligence.

It's a software system called VALDOCS. And it's designed on a whole new standard to make serious, useful computing no more difficult than typing. Someday all computers may be built this way. But for now, there's only one.

The Epson QX-10.

The manageable manager.

The QX-10/VALDOCS system was designed from the very beginning to handle the details of *human* existence in a remarkably straightforward, accessible, *human* manner. For all intents and purposes, it has already built into it all the software you will *ever* need to successfully manage the details of your life.

Consider what the standard configuration of VALDOCS will do:

- It's a full-function, sophisticated *word processor;*
- an information *indexer* for easy access to *files;*
- an *address book;*
- and an *electronic mail system.*
- It's also a *calculator;*
- an *appointment book* and *notepad;*
- an *event timer;*
- and a *clock and calendar.*
- It gives you an automatic *list of "things to do"*
- and lists your *schedules and itinerary.*
- Finally, it's a *business graph drawing system.*

That's what it does right out of the box; what you can make it do within minutes of unpacking it. Without buying additional software or writing your own programs in what amounts to a foreign language.

It's like suddenly being a computer expert; suddenly being smarter. You can do in minutes — and often with a single key — what may have



taken users of other systems days to learn, or hundreds of dollars in supporting software to accomplish.

You're overcome with an unmistakable feeling of power.

Simply stated, what the QX-10 does better than any other personal computer system in existence is to free you from manipulating the *computer*, and allow you to manipulate *information*.

And, after all, isn't that what you want a computer for?

The keyboard is the key.
The HASCI keyboard — short for Human Applications Standard Computer Interface — has been designed to place important fundamentals like STORE and RETRIEVE in plain view on dedicated function keys. Virtually every program in other computers does these fundamentals differently, and how to do these functions is hidden right down with the most obscure technical details.

The VALDOCS system.
What VALDOCS does better than any other software system currently available is to take the "interactive" concept to its logical conclusion; it asks you to make choices, then executes commands based on your decisions.

The *common sense* of such a system reduces the amount of time needed to master the QX-10 to a fraction of that needed for other computers: in effect it displays the message, "Press this key to perform this function; press that key to perform that function; or press another key to move on to something else."

No brochure, of course, can do justice to the VALDOCS system; to fully appreciate it, you must sit down at a QX-10 and *experience* it. But to appreciate the range of its capabilities, examine them one by one.

Word processing.
When you turn the QX-10 on, it comes to life as a word processor. And as such, it does everything you'd expect a word processor to do.

Of course you can add and delete words and sentences; shift copy blocks from one place to another; even locate a specific word or thought on documents ranging from a few words to multiple pages.

That's where most word processors stop. But not the QX-10.

The QX-10 allows you to format *exactly* the way you'd like your document to appear in print. So when you press the key labelled ITALICS, the type *cn the screen* changes to italics; when you press BOLD, it changes to boldface. With the QX-10, you can vary the SIZE of the type and even change the STYLE.

So when you press PRINT, your document is printed exactly the way you've already seen it on the screen. What you see is what you get!

Scheduling.

Scheduling, in its essence, is the manipulation of time. And the QX-10 makes it easy in a way that no appointment book, or calendar, or list of things to do ever could.

To begin with, the QX-10 always knows what time it is. The internal clock/calendar has a battery backup which keeps track of the date and time, even if the computer has been unplugged.

As a scheduler, the QX-10 works like a desk calendar, but gives you instant, electronic access to dates and times, past, present and future. It automatically opens to today's electronic "page," it allows you to make appointments, jot down notes and reminders, list things to do, or even set an alarm for yourself.

Most important — and useful — the SCHEDULE function is always available. If you're typing a letter in the word processing mode, for example, you can stop in the middle and book an appointment just by pressing the SCHED key; pressing it again returns you to the word processing mode, *right where you left off*.

Calculating.

To simplify the entering of numeric data, the QX-10 has a separate 10-key pad that lets you add, subtract, multiply and divide. Just like a calculator. Its decimal tab key allows you to automatically align columns of numbers. But the QX-10 can sum the numbers within a document



being word processed or place the total of a calculation at any point within a document. *That's* the sort of thing that makes the QX-10 usable.

Graphics.

Generally speaking, pictorial information (charts and graphs) is a lot easier to digest than numeric information (columns of figures). Fortunately, the QX-10 makes graphics very, very simple.

In the DRAW mode, the QX-10 allows you to create a line graph, a bar graph, or a pie chart. Based on your choice, it will ask you for pertinent information such as the names, range and intervals for each axis, and the numeric value of each data point to be charted or graphed. Once all the information is entered, it will automatically plot the coordinates and draw the graph, even superimposing different types of data on the same graph. It couldn't be easier.

Filing.

The block of File Control keys on the HASCI keyboard allow you to do everything you need to do with a finished document: STORE it; RETRIEVE it; MAIL it to someone else's computer electronically; or PRINT it on the printer. Each with the stroke of a single key.

But those functions can't hold a candle to the power of INDEX. In the QX-10/VALDOCS system, every document, every graph — *everything* is indexed by up to *eight* keywords of your choice. And instantly available.





Here's how it works: for every file, you assign a name up to eight words long. Like "Mom's Recipe for Thanksgiving Pumpkin Pie from Scratch," or "Personal Financial Statement for SBA Loan Application." When you need to, you can retrieve any file, using one or more of the keywords you assigned in the name. For example, "Mom's Recipe," "Thanksgiving," "Financial Statement," or "SBA," will give you all the documents having to do with those topics.

And *that* is the most astonishing and *useful* filing system you're ever likely to run across.

Electronic mail.
On the QX-10/VALDOCS system, sending information to, or receiving information from another computer starts with a single key. It provides you, in effect, with electronic "in" and "out" baskets, gives you an "address book" of your correspondents, even allows you to schedule transmission times to coincide with less expensive telephone rates. Best of all, VALDOCS handles all your electronic mail functions without interfering with any of the other computer functions. So you can word process, calculate or graph while VALDOCS handles your mail.

System controls.
Say you're in the middle of a project and you don't know what to do next; or you give the computer a command and then wish you hadn't; or you want to stop some function the computer is performing — now. VALDOCS makes it easy.

The HELP key is always available to you, and can be pressed any time the system offers you a choice. The STOP key immediately stops whatever function the computer may have been performing; the UNDO key undoes the last thing you told it to do — so you can *un*-select a function, or even *un*-delete a file.

CP/M compatibility.
The Epson QX-10 has a side benefit that's going to make it very popular with some people — it's CP/M 2.2 compatible. Which means that most any CP/M software you have — or would like to have — will run on the QX-10. Most of these will be accessible under the MENU key which displays a menu of all the non-VALDOCS programs on file, in English, and lets you select the one you wish to run.

State-of-the-art hardware.
Up to now, we've only talked about what the QX-10/VALDOCS system *does* for you, because after all, *what* a computer does is far more important than *how* it does it.

But in order to create a system like the QX-10, we've had to come up with some of the most advanced — and spectacular — hardware on the personal computer market.

When you unpack the QX-10, here's what you get: a detachable HASCI keyboard with its own



processor; an ultra high resolution monochrome display; two ultra thin 5¼" disk drives with a capacity of 340K bytes per disk; a Z80 microprocessor with 256K of main memory; a separate display processor chip with 128K of video-dedicated memory; a DMA controller; an interrupt controller; a built-in calendar/clock with battery back-up, an RS-232C interface; a parallel printer interface; a light pen interface; internal space for up to five peripheral cards; and the VALDOCS software package.

All that for *under* $3,000.

Frankly, none of the so-called "third generation" microcomputers will do for you what the QX-10/VALDOCS system will do. And all of them cost more; some of them cost a lot more.

But for the price, none are more advanced.

The QX-10 video display features both bit mapping and the more usual character operation. The bit mapping allows multiple type fonts or high resolution graphics to be displayed on the screen in a remarkable 640 by 400 dot format — a feature available in only a few of the world's highest-priced systems. To get this performance, we turned to a new 16-bit video controller chip from NEC to give us the additional "oomph" we needed. But the central processor is the 8-bit Z-80, instantly compatible with the world's largest base of software — CP/M. Our five expansion slots are not used for *any* of this performance.

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Epson is best known in the U.S. for its full line of printers. We're known for the fact that every third dot matrix impact printer sold in this country has our name on it; for the fact that we make more printers and print mechanisms than all the other manufacturers in the world combined; and for the fact that Epson printers have a reliability rate of over 98%.

But that doesn't mean we're new in computers. Not by a long shot. Epson has been building and selling fine quality business computers in other countries since the 1970's, and we have a history of precision manufacturing dating back more than a hundred years.

The most important component is you.

You don't buy a computer for how "smart" it is. You buy one for how smart it makes you.

The Epson QX-10 was conceived, designed, engineered and built with just one thought in mind: to vastly expand your ability to see, to think, to create with a system that acts as a natural extension of the human mind.

And the critics agree the design concept is one of the best they've seen.

The QX-10 is not a computer designed to play games, although it plays games as well as any and better than most.

It's a computer for people who think.

And who want to think better.



SPECIFICATIONS

CPU and Memory	
Main CPU	Z80A Microprocessor, 4 MHz Clockrate
Main Memory	64K to 256K RAM
CMOS Memory	2K RAM Battery Backup
IPL	Up to 8K
Controllers	
Video/Graphic	NEC 7220 Graphic Display Controller
Disk	Double Density Floppy Disk Controller
DMA	Programmable DMA Controllers 1 Main System } 7 DMA Channels 1 Option Slot }
Interrupt	Programmable Interrupt Controllers (15 Interrupt Levels)
Control/Timer	Two Programmable Interval Timers
Printer I/F	Programmable Parallel Interface
Serial I/F	Multi-Protocol Serial Controller
Clock	CMOS Realtime Clock/Calendar with Battery Backup
Display	12" Green Monochrome High-Resolution Monitor 640 x 400 Pixels 80 characters x 25 lines Non-Glare Screen Dedicated Memory 32K or 128K
Mass Storage	Two 5¼-inch, Double Sided Floppy Disk Drives; Capacity: 340K Per Disk
Detachable Keyboards	ASCII HASCI

Interfaces	
Serial	RS-232 Programmable, DB-25 Connector, Synchronous or Asynchronous
Printer	Standard Parallel
Light Pen	
Option slots	Five
Speaker	Controlled by Countertimer
Environmental Requirements	
Temperature	Operating Range 41° to 104°F (5° to 40°C) Storage Range 22° to 158°F (−30°C to 70°C)
Humidity	Operating Range 10% to 80% Non-Condensing Storage Range 10% to 90% Non-Condensing

Physical Characteristics

Size	CPU	Monitor	Keyboard
Width	20.3 in (508mm)	12.4 in (312mm)	20 in (510mm)
Depth	13.6 in (340mm)	13.6 in (340mm)	8.9 in (224mm)
Height	4.1 in (103mm)	10.6 in (266mm)	1.9 in (49mm)
Weight	20.6 lb (9.4kg)	12.1 lb (5.5kg)	5.5 lb (2.5kg)

Power Requirements 115 VAC, 60 Hz; with Switching Power Supply
100 Watts

Specifications subject to change without notice.

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Jones: "But what about our reputation? We've been leaders in serving the business and financial community for over 100 years. Are you sure this new software will be as reliable as The Wall Street Journal and Barron's?"

Dow: "Of course, Jones. Our software is so reliable we back it up with a full-year warranty. People trust Dow Jones Software the same way they trust the Journal. And we have a toll-free Hotline number in case they want expert help."

Jones: "Couldn't that be a lot of phone calls? After all, we've got the Dow Jones Averages to get out every day."

Dow: "Don't worry, Jones. Our software is very easy to use, and we have a fully staffed Customer Service Department to respond to our dealers and customers."

Jones: "Just what can our software do?"

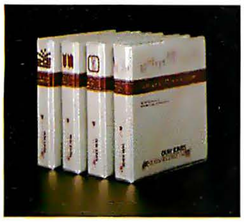
Dow: "In a nutshell, Jones, with a personal computer, a telephone, a modem and Dow Jones Software, you can easily perform complex analyses on the information available from our information service, Dow Jones News/Retrieval®."

Jones: "People really use our software to make decisions?"

Dow: "Absolutely. Once you've stored the information you want, our software does the rest. For instance, with one Dow Jones Software product you can follow indicators for stocks, sort, rank, screen and set critical points for buying and selling. With another, you can easily construct technical charts. Look at this beautiful graph."

Jones: "You mean all those calculations I've been doing by hand I could do in a fraction of the time with this software? That's great!"

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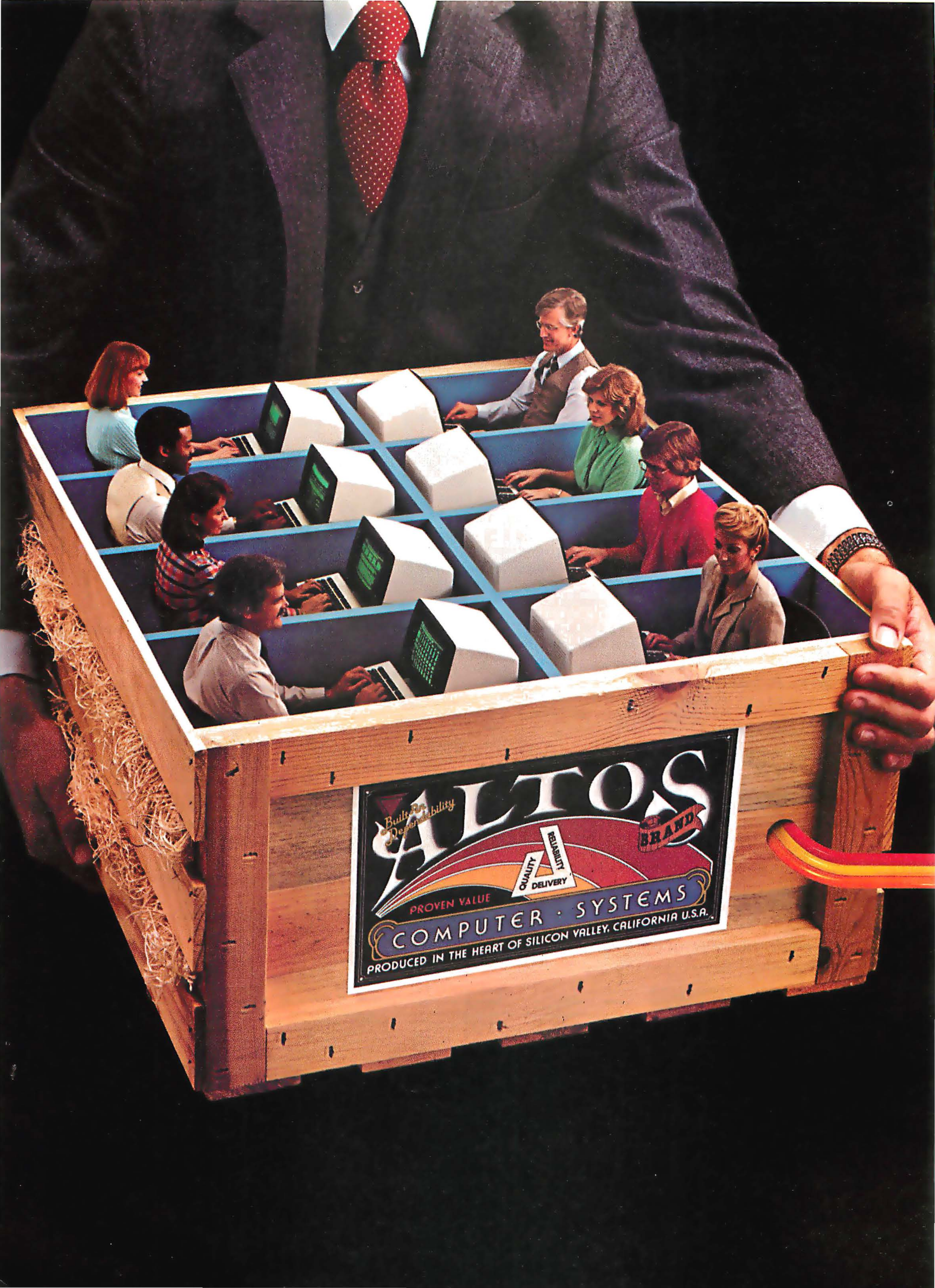
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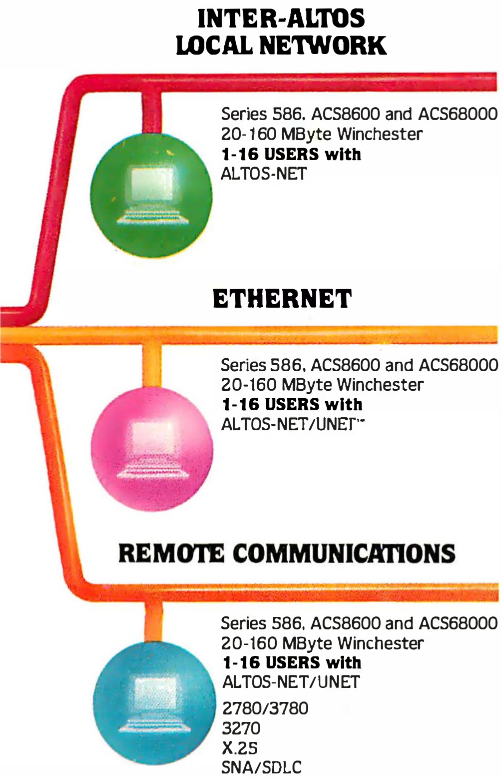


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Altos also has high-level languages (BASIC, FORTRAN, COBOL and PASCAL), and applications software (ABS/86 and ABS/68 for general accounting, word processing and financial planning).

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IBM's "Secret" Computer

The 9000

IBM Instruments Inc. manufactures a 68000-based instrumentation computer that could become a powerful business machine.

Chris Morgan
Editor in Chief

The best-kept secret of 1982 may have been that IBM makes a 68000 computer. If that surprises you, you're not alone. The unit, called the IBM Instruments Computer System, is IBM's second major microcomputer product—the first, of course, is the IBM Personal Computer. The 9000 made its debut in June 1982 at the COMDEX show in Atlantic City, even though it was publicly announced the previous month by IBM's subsidiary, IBM Instruments Inc., in Danbury, Connecticut. The announcement was so unhyped that few people took notice.

The machine is marketed as a laboratory instrumentation computer, yet its design innovations and modularity make it a natural candidate for a business or general-purpose computer—with the appropriate engineering and cosmetic changes, of course. IBM has declined to comment on this possibility, however.

In this article I'll describe the features of the machine, which I saw during a recent visit to the IBM Danbury facility, and speculate about the impact of a 68000-based microcomputer from the world's largest computer company.

Features

The IBM 9000 is well suited to the laboratory: its modular construction revolves around a basic chassis containing a processor board, a 12-inch black-and-white CRT display, and a 57-key keypad, all included in the $5695 price. The 9000 has been engineered with crowded lab benches in mind: the modules stack vertically to conserve space. When augmented by the printer/plotter, keyboard, and a host of other options, the 9000 becomes a powerful 16-bit computer system. A full-blown configuration typically costs $10,000 or more.

Design Methodology

Why has IBM decided to offer a 68000 computer? To answer that question, I interviewed the machine's designers at IBM Instruments, a recently acquired, wholly owned subsidiary of IBM. For years it has been active in the design of computer-oriented laboratory equipment. The division's status as a separate profit center within IBM allows it to experiment more freely with unusual computer designs—in particular, development of a laboratory-oriented microcomputer.

The incentive to do this came from a major change in the instrumentation field. During the 1970s laboratory techniques such as nuclear magnetic resonance and gas chromatography became more popular—techniques that required masses of sophisticated mathematical calculations. These calculations demanded more in the way of mathematical analysis than 8-bit computers could deliver. For example, fast Fourier transform (FFT) analysis (a common mathematical technique in the laboratory) consumes huge portions of memory. Thus laboratories had to stick to more expensive but powerful minicomputers. A real need arose for ways to improve the productivity and cost-effectiveness of data acquisition and processing in the laboratory.

So the IBM 9000 was born. It has the memory space (up to 5 megabytes of RAM!) to handle sophisticated labora-

Text continued on page 104

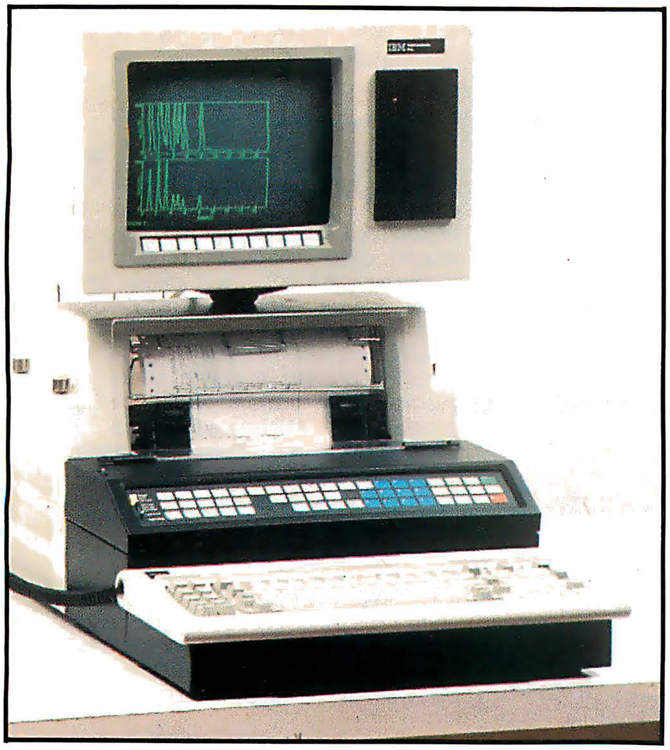


Photo 1: *The new IBM 9000 Instrumentation Computer, manufactured by IBM's instrumentation division in Danbury, Connecticut. The machine uses the Motorola 68000 processor and includes (in this implementation) a 12-inch CRT display, a 57-key keypad with user-definable keys, an 83-key keyboard, four-color printer/plotter, custom IBM multitasking operating system, five I/O ports, disk controller for up to four 5¼-inch or 8-inch floppy-disk drives or hard disks, Versabus interface, and room for up to 5 megabytes of RAM onboard. The implementation shown in the photo costs close to $10,000.*



Photo 2: *Close-up of the 57-key keypad (at top) and the 83-key keyboard on the IBM 9000.*

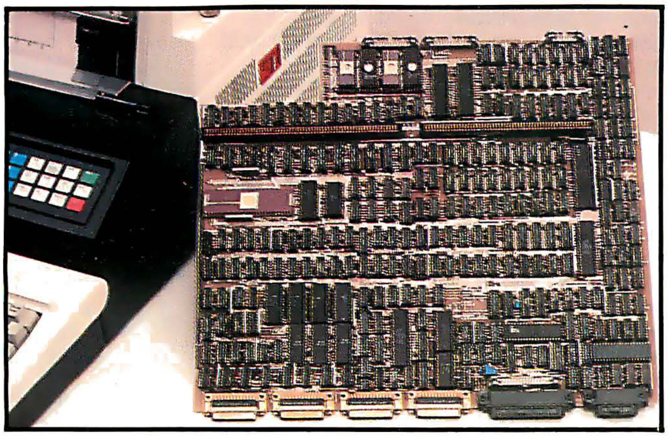


Photo 3: *The IBM 9000 seven-layer planar processor board, showing the remarkably dense population of ICs and VLSIs. This state-of-the-art board has over 1600 test points and could not have been manufactured just over a year ago because of the density of the components. By plugging in an optional expansion board, up to five Versabus (a 32-bit bus standard developed by Motorola) cards can be plugged into the main board.*



Photo 4: *The stripped-down version of the IBM 9000, with CRT display, 57-key keypad, processor board, and chassis, retails for $5695.*

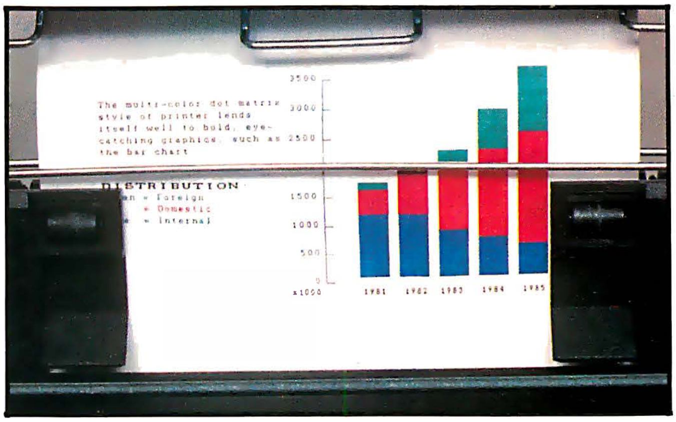


Photo 5: *Close-up of output from the dot-matrix printer/plotter, which features four-color printing, 200 characters per second in draft mode, and 220 by 336 dots per inch of resolution.*

At a Glance

Name
The IBM Instruments Computer System

Manufacturer
International Business Machines
IBM Instruments Inc. Division
Orchard Park
POB 332
Danbury, CT 06810

Components
Basic System Module
(comprises processor board, CRT display, keypad, and chassis)

Size: width 22.3 inches, depth 17.2 inches, height 23.2 inches (with CRT display positioned on bridge); weight (main chassis alone): 31.5 pounds; weight with CRT, printer, and keyboard added: 78.8 pounds

Electrical needs: 120 volts AC

Processor:	Motorola 68000, with 32-bit registers/16-bit data flow; 24-bit addressing (up to 16 megabytes)
Memory:	128K bytes of RAM; up to 128K bytes of ROM
Keypad:	57 keys for data entry, arranged in three color-coded rows, pressure-sensitive type with audible click; all keys are user-definable, and six keys have LEDs under program control
CRT display:	12-inch raster-scan type with 768- by 480-pixel bit-mapped display, 80 characters by 30 rows, green-on-black display; 10 user definable keys beneath the display with user-chosen legends at bottom of screen; display has unique single-lever tilt and swivel adjustment
Interfaces:	IEEE-488 interface, standard bus, 1-MHz operation; three RS-232C serial ports, ASCII coded, asynchronous, 19,200 bps maximum data rate, software-settable parameters; one 8-bit parallel bidirectional port with hand-shaking signals and TTL-level signals
System bus:	superset of Motorola Versabus; main board accepts up to five Versabus cards via attachable expansion card; 32 programmable interrupts on four hardware levels; seven hardware levels total; four channels of DMA at 1 MHz maximum
Standard software:	IBM custom operating system, with real-time, multitasking nucleus; drivers for I/O (input/output) including CRT, printer, sensors, etc.; graphics; file handling and disks; debugger; and diagnostics
Miscellaneous:	three built-in 16-bit timers with up to 2-MHz pulse source; built-in real-time clock with battery backup

Options

Printer/plotter:	impact, dot-matrix type, bidirectional; 200 characters per second in draft mode; plotting resolution: 220 by 336 dots per inch; four-color ribbon; accepts 8½- by 11-inch regular paper or 9½-inch pinfeed fanfold paper; unit mounts in processor unit chassis
Keyboard:	83-key keyboard, virtually identical to IBM Personal Computer keyboard; has full ASCII character set with numeric keypad (not to be confused with 57-key keypad on main chassis); cursor control, print control, 10 programmable function keys (distinct from softkeys on CRT display); automatic repeat on all keys; keyboard is movable, with detachable 6-foot coil cable
Disk drives:	up to four drives in any combination; available in 5¼-inch size: double-sided, double-density, 327K bytes formatted, 250,000 bits/second transfer rate. In 8-inch size: double-sided, double-density, 985K bytes formatted, 500,000 bits/second transfer rate, IBM standard format
Expansion card:	system bus card with five additional Versabus card slots
Additional memory card:	up to 1 megabyte per card in increments of 256K bytes; 500-nanosecond access time; memory includes single-bit error checking in hardware
Hard-disk controller card:	controls up to four 5¼-inch 5-megabyte and/or 10-megabyte formatted hard-disk drives, 625,000 bytes/second transfer rate, using SA1000 and ST506 interface
Analog sensor card:	available in five versions
Software options:	BASIC with extensions; operating system extension on disk; editor; macroassembler; linker/loader/librarian; disk utilities; chromatography application program
Planned future software:	FORTRAN 77 compiler; Pascal compiler; mathematics/statistics package; communication capabilities through IBM 3101 and 3270 emulation software; full-screen editor

Hardware Prices

Basic unit (with processor board, keypad, CRT)	$5695
Memory expansion card with 256K bytes of RAM	1095
Additional 256K bytes of RAM expansion	995
Single 5¼-inch disk drive mounted in display	650
Cabinet with one 5¼-inch disk drive	795
Additional 5¼-inch disk drive	650
Cabinet with one 8-inch disk drive	1495
Additional 8-inch disk drive	975
Hard-disk controller	1295
5-megabyte hard-disk drive with cabinet	2495
Additional 5-megabyte hard-disk drive	1995
10-megabyte hard-disk drive with cabinet	2695
Additional 10-megabyte hard-disk drive	2195
Keyboard	270
Printer/plotter	2095
Sensor board "A"	850
Expansion feature with five slots	95

Software Prices

BASIC language	$195
Operating system extensions	155
Chromatography applications package	495

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GOOD NEWS



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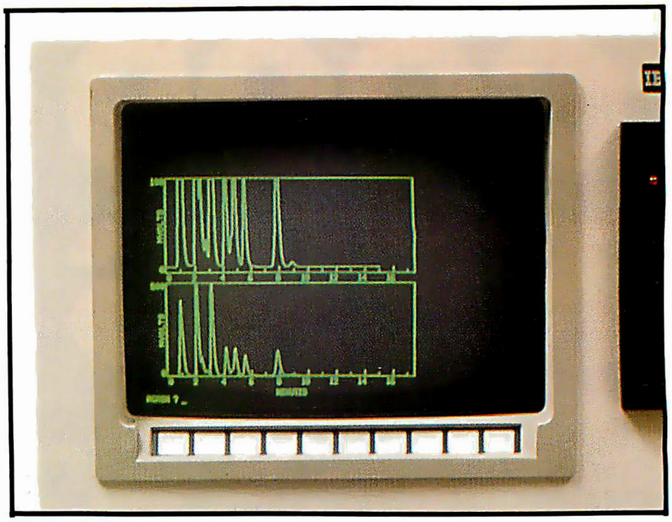
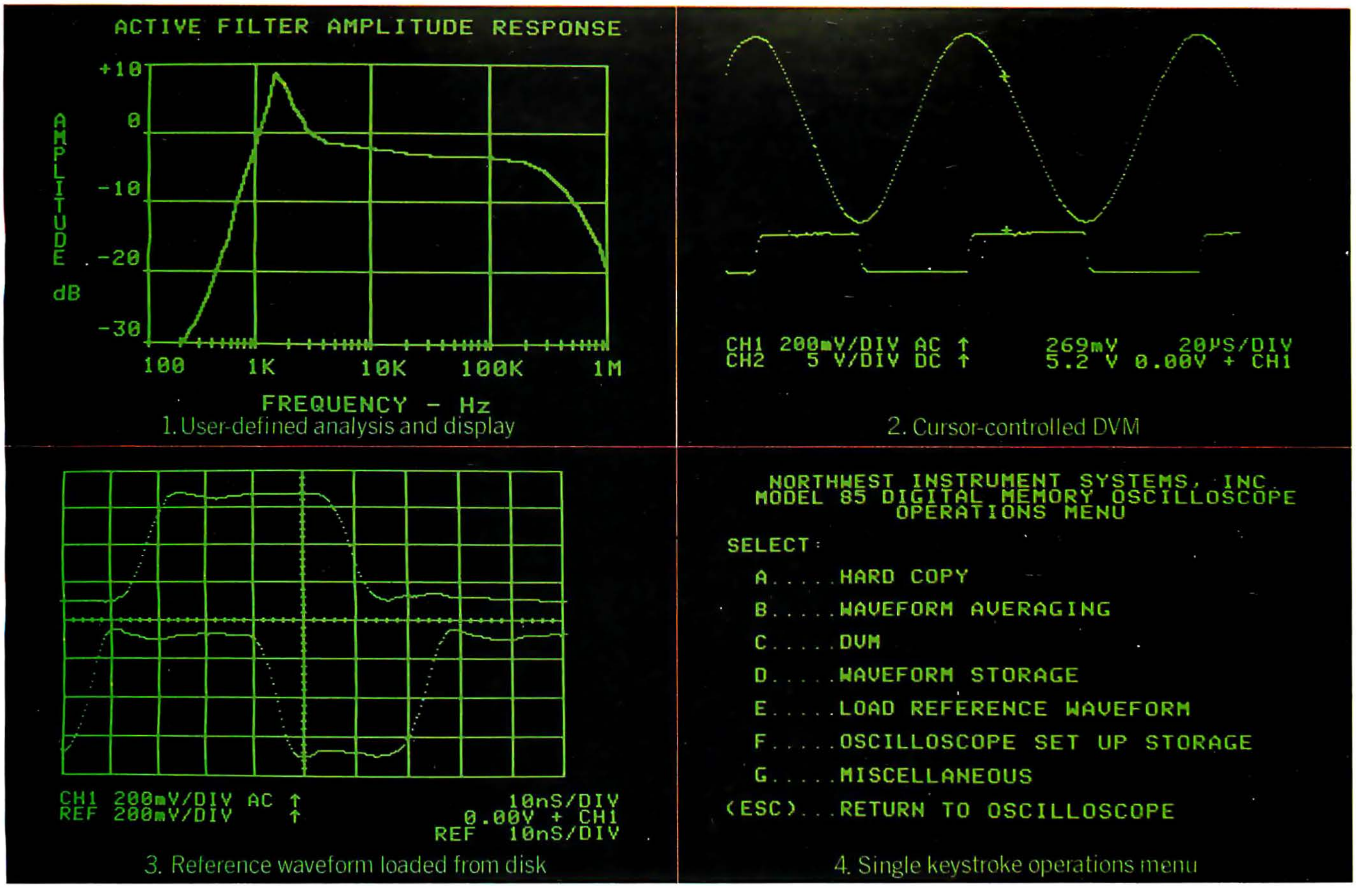


Photo 6: *Close-up of the 12-inch, green-on-black raster-scan CRT display, with 768- by 480-pixel bit-mapped display and 80 characters by 30 rows. Ten user-definable keys are located along the bottom of the display, with user-chosen legends on the screen. The display has a unique single-lever tilt and swivel adjustment.*

tory mathematics. It has modular hardware features needed in the lab, such as a high-resolution color printer to create graphs and charts, a swiveling CRT display, and a movable keyboard that can go where the experiment is. More important, it has the Motorola 68000, a powerful 16-bit processor. Long a favorite with many software designers, the 68000 was chosen by IBM despite the fact that the IBM Personal Computer uses the Intel 8088 processor (which is not a true 16-bit processor). The 68000 won out mainly because of its superior benchmark performance. According to its designers, the 68000 gives the 9000 a better price/performance ratio and provides a standard method to control all IBM instruments. The 9000 has real-time multitasking capability—important in data acquisition—and its five I/O interfaces allow it to be easily connected to a variety of laboratory instruments.

The real star of the 9000 is its remarkable state-of-the-art planar processor board. Seven layers deep, it is literally crammed with ICs and VLSIs to the saturation point. IBM says the board could not have been manufactured just over a year ago because of its high chip density (the board has more than 1600 test points). On this single board are the complete computer, five I/O ports, the disk controller, and slots for an auxiliary expansion card that will hold up to five Versabus cards. The advantage to single-board construction is the freedom from printed-circuit board connection points—a major source of computer failure. (Incidentally, IBM will swap processor boards with customers in an overnight service in case of hardware failure.) The 32-bit Versabus ensures compatibility with future instruments. In addition, the Versabus stands an excellent chance of becoming a standard bus in the future.

One look at the 9000's processor board reveals its



1. User-defined analysis and display
2. Cursor-controlled DVM
3. Reference waveform loaded from disk
4. Single keystroke operations menu

WHICH OF THESE DISPLAYS WERE GENERATED BY A PERSONAL COMPUTER?

Every single one of them. And not just generated, either. The instrument settings were configured, signals acquired, and analysis performed via a personal computer, also. An Apple II®, to be specific. Equipped with Disk II®, 48K memory, DOS 3.3 and a remarkable, make that revolutionary, engineering breakthrough known as the Model 85 aScope™. Remarkable because aScope transforms any computer in the Apple II series into a dual channel, DC to 50 MHz repetitive signal bandwidth (25 KHz real time sampling rate), fully programmable, digital memory oscilloscope. Revolutionary because it does all this for less than $1,000.

The way we achieved this cost reduction was by not following the path of conventional instrument architecture, combining a stand-alone programmable oscilloscope with a general purpose computer controller. Instead, we integrated. Making aScope a peripheral. Supplying only what was needed to make the personal computer a high performance instrument.

Result? An oscilloscope system that allows you to configure a setup, define the analysis you desire and produce an end result display in the most useful format. Many frequently performed routines are already part of aScope's software. But more importantly, the system's architecture is designed to accommodate considerable user modification via co-resident BASIC or assembly language programs. (One example: the user-defined program to plot the amplitude response of an active filter shown in display 1 above.)

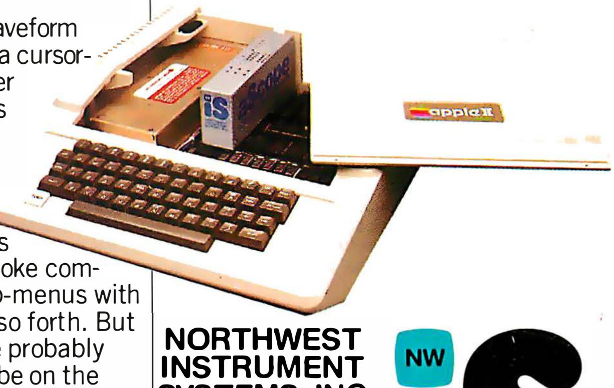
aScope will average waveforms. Store waveforms on disk in binary or text files. Store instrument settings for automated setup. Or load and display a reference waveform from disk (display 3 above).

aScope also delivers waveform voltage readings utilizing a cursor-controlled digital voltmeter (display 2). And generates hard copy via an Epson MX-80™ or Silentype® printer.

Space permitting, we'd go on about aScope's menu driven single keystroke commands (display 4), its sub-menus with complete prompting and so forth. But frankly, we suspect you're probably as intrigued as you could be on the basis of one ad.

So here's how to find out more. Call 800-547-4445. This will provide you with the name of the aScope representative or authorized computer dealer in your area, as well as an opportunity to invest $10 in our comprehensive aScope demonstration disk.

The Model 85 aScope. We admit, the performance it delivers for the price is so remarkable, it may initially strike you as unbelievable. But then, when you think about all the breakthrough products this industry has seen over the last decade, sounding unbelievable at first is almost a tradition.



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designers' eclectic approach: it contains ICs from over a dozen U.S. and Japanese companies—Advanced Micro Devices, Signetics, Motorola, National Semiconductor, Texas Instruments, Intel, Intersil, Hitachi, Western Digital, and others. Each chip was chosen for its specs alone. This would have been heresy back in IBM's monolithic days, when practically every IC inside an IBM computer was custom made by IBM.

Other Features

In addition to the RAM and ROM within the machine, a 64K-byte (12-bit word) graphics memory handles the screen display; the Motorola 6845 CRT controller chip manages the display logic in the IBM 9000. Other features include a memory-protect scheme (useful in multitasking applications) and composite video.

The IBM 9000 automatically conducts a power-on diagnostic routine, and a second diagnostic routine can be initiated by the user.

The CRT display has excellent resolution (768 by 480 pixels) and one felicitous feature: a single handle control that lets you quickly shift the position of the display horizontally and vertically by merely pulling the handle toward you and repositioning the screen. Beneath the screen is a row of user-definable keys like those on Hewlett-Packard machines. The printer/plotter is well suited to the 9000, with 220 by 336 dots per inch and excellent four-color printing.

The 57-key user-definable keypad is perhaps the 9000's oddest feature; yet having that many user-definable keys could be a boon for some applications. One spectator at the COMDEX show suggested using the keys to represent Wordstar commands. Though I'm no fan of this type of touch-sensitive key, I suppose it does the job.

The 9000 operating system (custom designed by IBM) has multitasking capability and a sophisticated I/O manager that queues up all I/O requests. The software is menu driven with keyword bypass for the expert user. The system features contiguous file allocation to minimize access time, and the various high-level languages (BASIC, Pascal, and FORTRAN 77) all share a common graphics interface—a decided plus.

Laboratory-oriented software available includes a gas chromatography program. A nuclear magnetic resonance station is also available for $250,000.

Speculation

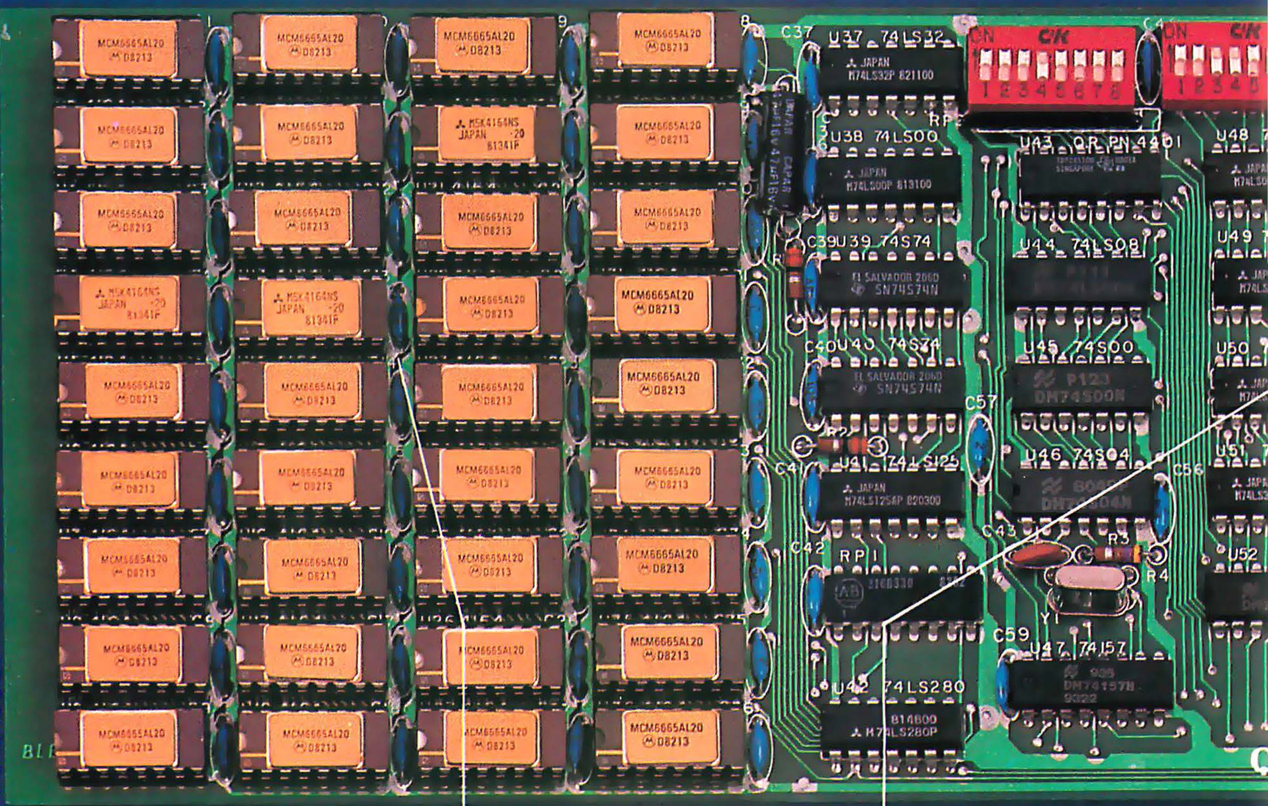
The IBM 9000 is ideally suited to the laboratory. But it strikes me that the 9000's processor board could become the heart of a general-purpose microcomputer for the business market. As I said earlier, IBM is not commenting on this speculation. (Incidentally, IBM 9000 customer deliveries should have begun by the time you read this.)

I think the 9000 is, in its quiet way, one of the most exciting new arrivals on today's microcomputer scene. I predict it will start showing up in all sorts of unexpected applications. In one gesture IBM has legitimized a microprocessor that deserves more attention: the Motorola 68000. ■

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Socketed and expandable in 64K increments to 256K, full parity generation and checking are standard. A Quadboard exclusive feature allows parity to be switch disabled to avoid lock-up upon error detection. The dip switches also allow it to be addressed starting on any 64K block so that it takes up only as much as it has memory installed. Memory access and cycle time naturally meet all IBM specifications.

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Quadboard eliminates the hassle of manually inputting the date on system boot-up by providing for the clock and all software routines necessary for inserting the appropriate programs on your diskettes. The internal computer clock is automatically set for compatibility with most software routines which utilize clock functions. On-board battery keeps the clock running when the computer is off.

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A 16 pin header on Quadboard is used for inserting a short cable containing a standard DB25 connector. The connector is then mounted in the knock-out hole located in the center of the PC backplane. The parallel port can be switch disabled or addressed as Printer 1 or 2. No conflict exists with the standard parallel port on the Monochrome board. The internal cable, connector and hardware are all included.

ASYNCHRONOUS (RS232) COMMUNICATION ADAPTER.
Using the same chip as that on the IBM ASYNC board, the device is software programmable for baud rate, character, stop, and parity bits. A male DB25 connector located on the back connector is identical to that on the IBM Async Adapter. The adapter is used for connecting modems, printers (many letter quality printers require RS232), and other serial devices. Switches allow the port to be configured as COM1 or COM2 and the board fully supports IBM Communications Software.

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Apple-Cat II

A Communications System from Novation

James A. Pope
458 Elm St.
Denver, CO 80220

A modem, of course, is merely a device used to convert digital signals into analog form and vice versa, thereby allowing computers to communicate with each other over telephone lines. Novation's Apple-Cat II, the latest in the "Cat" series of modems, has been promoted as not merely another modem but the base unit for a sophisticated "personal communications system" for the Apple II computer.

In this article I will discuss the product as it currently exists, describe some of the enhancements that are being developed, and give you some help in using the present system to its fullest extent.

At a Glance

Name
Apple-Cat II Communications System

Type
Modem for the Apple II Plus, expandable to a full communications system

Manufacturer
Novation Inc.
18664 Oxnard St.
Tarzana, CA 91356
(213) 996-5060

Price
Base system: $389; Options: Expansion Module: $39; Bell 212 upgrade module: $389; BSR X-10 controller: $19; Touch-Tone decoder: $99; ROM firmware chip: $29

Computer
Apple II Plus, with 48K bytes of RAM (random-access read/write memory) and one disk drive; printer (optional)

Hardware
Base system: single circuit board, telephone cable, and telephone sockets; Options: Bell 212 protocol expansion board, BSR X-10 controller, telephone handset, Expansion Module, Touch-Tone decoder chip, firmware ROM (read-only memory) chip

Software
Single disk, DOS 3.2, copyable, containing a terminal operation program, test programs, and file-conversion programs

Features
300 bps full-duplex (Bell 103) transfer, 1200 bps half-duplex (Bell 202) transfer, auto-answer, 27K-byte buffer, status display line, onboard RS-232C port

Audience
Apple II users who want to transfer data over telephone lines

"1200 Baud"

Like many companies, Novation has planned its product development in such a way as to provide for future expansion. This includes the wording of certain pieces of advertising copy. For example, the early advertising and sales materials for the basic Apple-Cat II system claimed speeds of "0–1200 baud." You will indeed be able to communicate with someone at 1200 baud (or to be more precise, 1200 bits per second or bps), but you may have trouble finding someone to communicate with.

The Apple-Cat II can transmit at 1200 bps, but only with the Bell 202 protocol that very few computers use anymore (see text box on page 112 on 1200-bps protocols). Of the 1200-bps protocols, the Bell 212 and Racal-Vadic VA3400 are much more popular. This means that 300 bps is likely to be your maximum transmission rate unless you are talking to another Apple-Cat using Bell 202.

Fortunately, by the time you read this an add-on card will be available

Anadex SILENT/SCRIBE™ printers. Quietly going about your business.



Now and then office noise levels can go sky-high. But with Silent/Scribe – our new family of matrix impact printers – you can raise your printer expectations while significantly lowering your office noise level.

How quiet is "silent"? Silent/Scribe operates at less than 55 dBA, which means that in the average office you may have to look at it to determine whether it's printing.

SILENT/SCRIBE MODELS

Standard Features	Char. per Inch	DP-9000A	DP-9500A	DP-9001A	DP-9501A	DP-9620A
Printing Speed (Char. per Sec.)	10	150	150	120	120	200
	12	180	180	—	—	120
	12.5	—	—	150	150	—
	13.3	200	200	—	—	—
	15	—	—	180	180	150
	16.4	—	—	200	200	164
Enhanced	10	—	—	—	—	100
Expanded Print (Double Width)		Yes	Yes	Yes	Yes	Yes
Dot Addressable Graphics (Dot/In., H/V)		60/72	60/72	75/72	75/72	72/72
Max. Line Width (In.)		8.0	13.2	8.0	13.2	13.2
Audible Alarm		Opt.	Opt.	Opt.	Opt.	Yes
Out-of-Paper Sense		Yes	Yes	Yes	Yes	Yes
Ribbon, Continuous Loop Cartridge (Yds)		30	30	30	30	30
Interfacing: Parallel Cent. Comp.		Yes	Yes	Yes	Yes	Yes
RS-232-C Serial		Yes	Yes	Yes	Yes	Yes

And Silent/Scribe is as easy to buy as it is to live with. You can select a variety of printing speeds, fonts and line widths. Some models provide both draft and enhanced quality copy. All models have superb dot-addressable graphics at no extra cost.

Also standard are sophisticated communications controls and protocols, flexible and easy-to-use operator controls, quick-change continuous loop ribbon cartridge, and universal interfaces that work with virtually any computer system.

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1200 bps:
Half- vs. Full-duplex

The most popular mode of transmitting data to and from personal computers over telephone lines is the Bell 103 protocol, which transmits data at the rate of 300 bps (bits per second) or about 30 characters per second. Three protocols for 1200-bps data transfer are available, however: Bell 202, Racal-Vadic VA3400, and Bell 212.

Bell 202 was the first of these high-speed protocols, but it can send data in only one direction at a time. In other words, it is a half-duplex protocol. This method is difficult to use because, among other things, it is hard to determine the direction in which data is traveling. Bell 103, on the other hand, is slow (300 bps), but it can transmit data simultaneously in both directions (i.e., full-duplex, using both originate and answer channels) and is rather easy to use.

*Then came the VA3400 and Bell 212 protocols. These can transmit at 1200 bps in full-duplex mode, using both an originate channel and an answer channel just like the much slower Bell 103 protocol. Unfortunately, modems for these protocols require special phase modulation hardware that has caused them to be about two to four times more expensive than a Bell 103 modem. . . .*R.M.

that will enable the Apple-Cat II to use the full-duplex, 1200-bps Bell 212 protocol, but this will add about $390 to the price of the modem. Novation should make this point more clear in its advertisements.

The System

As I mentioned before, Novation has produced not just a modem for the Apple II, but a communications system that allows your Apple to "communicate with the outside world." As of this writing, however, Novation has not produced all of the additional components of such a system. The basic unit as it stands today gives you the following capabilities:

- Full-function, low-speed (0–300 bps), full-duplex, originate/answer

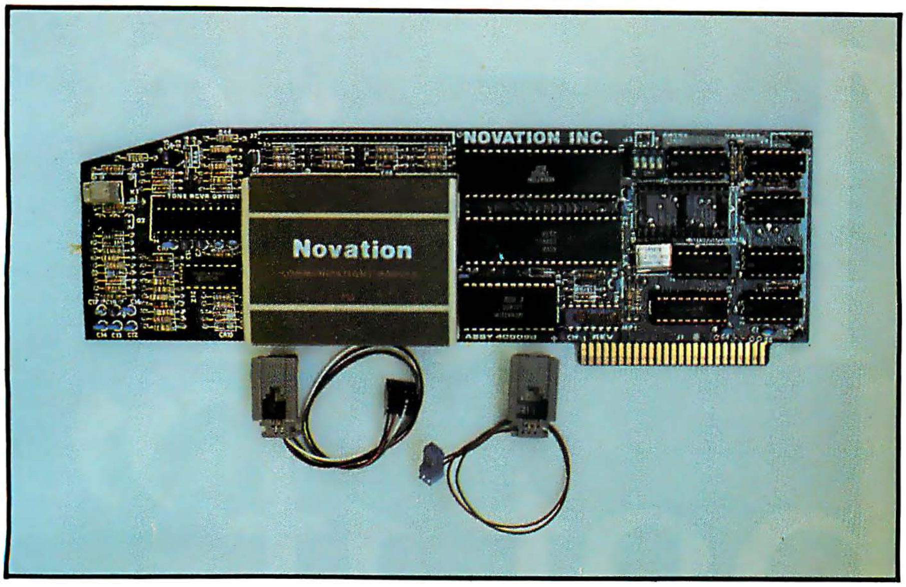


Photo 1: *The Apple-Cat II basic system circuit board with the telephone connector cables. The cables are connected to pins located along the top of the card. Also shown are the two empty sockets for chips. The one on the left is for the Touch-Tone receiver chip; the other one (near the upper right corner) is for firmware ROM chips. (All photos are by the author.)*

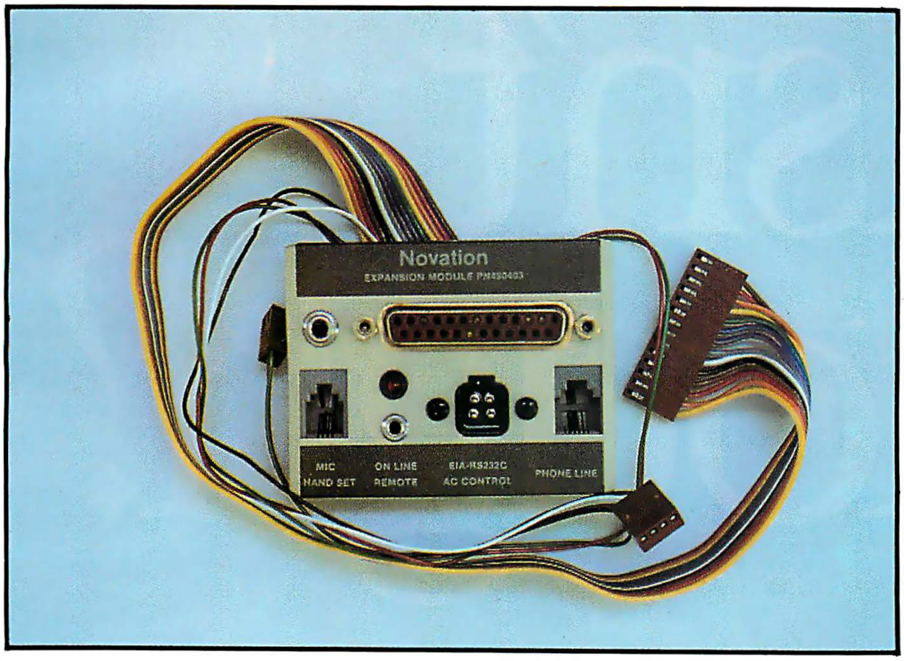


Photo 2: *The Expansion Module contains sockets for a modular telephone line and handset, an RS-232C connector, a BSR X-10 controller, and a tape recorder. Also present is an LED to indicate an "off-hook" condition. The module mounts on the back of the Apple with double-sided tape and connects to the Apple-Cat II via the three cables shown here (the single pair for the phone line, the double pair for the handset, and the ribbon for the rest).*

modem capabilities which, with the software provided, allow you to set up a very intelligent terminal.

- Full-function, 0–1200 bps communication through an RS-232C port allows for in-house transfer of information.
- Data may be transferred at 1200 bps (half-duplex, Bell 202) over phone lines to another Apple-Cat II system.
- With the addition of a standard telephone handset (optional), you can use the Apple-Cat II as a telephone or change to voice communications before or after a data transfer to another computer.
- A 27K-byte memory buffer is available for data-transfer storage.
- The system offers a high capability for expansion.

Installation

The Apple-Cat II is fairly easy to install. When you open the box you will find a single printed-circuit board (see photo 1), two modular telephone sockets (RJ11), a telephone cord, and a manual. The circuit board can be inserted into any slot other than slot 0 (although slot 2 is best for reasons I'll explain soon). One of the telephone sockets is for the telephone line, and the other is for the optional telephone handset. Both of the telephone sockets have attached wires that must be plugged into the circuit board. After these are connected, the sockets themselves are slid into the slots in the back of the Apple and the appropriate telephone cables are plugged in.

If you are like many Apple owners, however, the several cables you probably already have coming out of the back of your machine may not leave enough room for the two sockets to fit in the slots. The optional Expansion Module (see photo 2) eases this problem somewhat. This unit contains telephone sockets, tape recorder jacks, "off-hook" LED indicator, BSR X-10 controller connector, and RS-232C port. When installed (see photo 3), this unit saves quite a bit of space and also allows you to take advantage of future developments. It really should have been part of the basic system, but $39 is a reasonable price to pay for the convenience this unit provides.

Documentation

The documentation for the Apple-Cat II is adequate but not exceptional. Editing and organization are the primary problems. For example, general specifications given early in the manual are contradicted later on. The use of green blocks with inverse type for highlighting and green ink to distinguish the computer responses is a nice idea, but it's not well executed—the effect makes the manual

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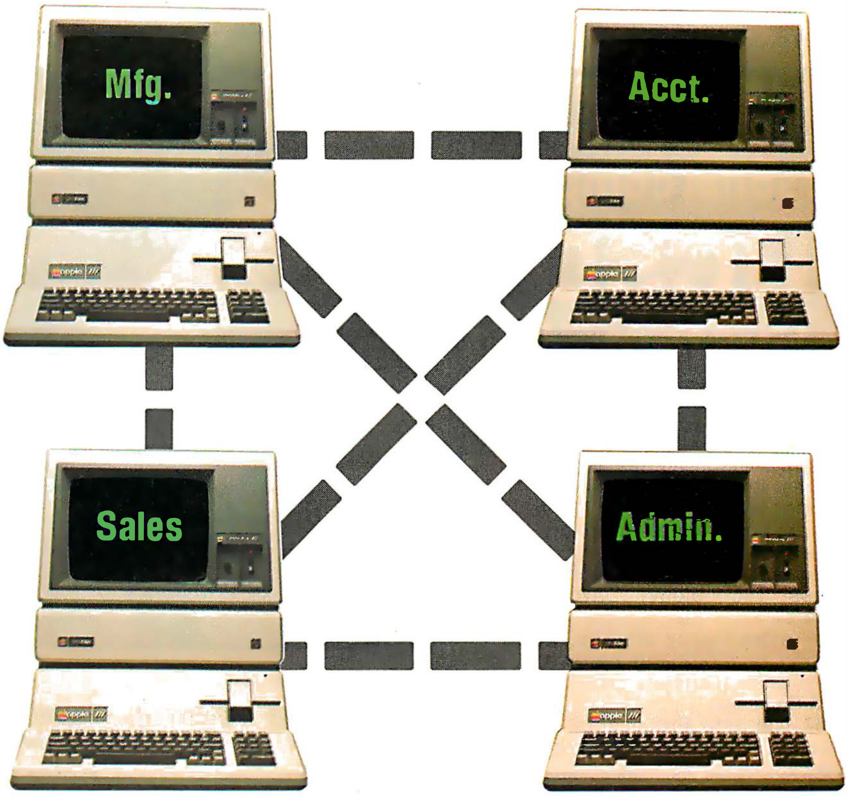
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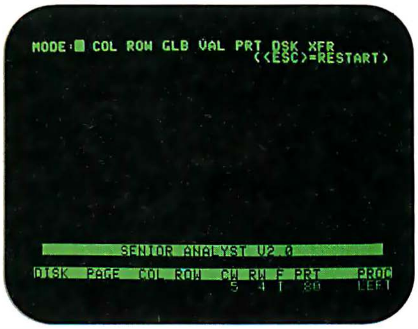
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Circle 30 on inquiry card.

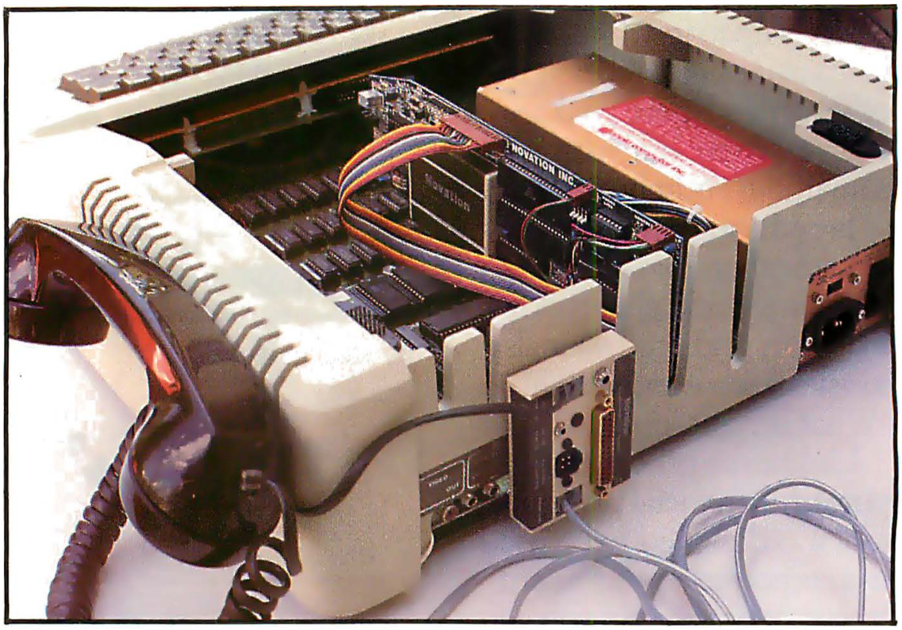


Photo 3: *The Apple-Cat II and Expansion Module installed. Using the Expansion Module reduces cable clutter. The author has turned the unit sideways to permit full use of the adjacent slot on the back of the Apple.*

hard to read. Also, some portions seem to be missing. But all in all, reading the manual will teach you how to use the basic system.

The Com-Ware II Program

Unless you are a fairly sophisticated 6502 assembly-language programmer, the only way you can currently use the Apple-Cat II is with Com-Ware II, the software package provided with it. Other packages that are compatible with Apple-Cat II, such as ASCII Express: The Professional System and Visiterm, have come out recently, but in this review I will focus on only the Com-Ware II program.

If you didn't insert the circuit board into slot 2, your Apple II will sound an alarm the first time you boot the software disk. The reason is very simple—a configuration section of the terminal program has certain defaults set when it is created, and the default slot number is 2. If the card is not in that slot, the program will tell you so. When this happens, call the terminal configuration program and change the slot number. The command for this and any of the other functions is a single keystroke.

The terminal configuration program sets the various operating parameters, including card location, tone or pulse dialing, Touch-Tone decoding, input/output selection (modem or port), operating mode, speed, number of data bits, number of stop bits, parity type, and uppercase or lowercase display. Any of the parameters may be changed while the system is online. A list of the various Com-Ware II program functions is shown in table 1.

The actual operation of the Apple II as a terminal is uncomplicated. Files may be transmitted in text or binary form, and program files can be converted to binary using a routine provided. (They will have to be changed back after being received by the other system, however.)

A helpful feature is a status line that appears on the bottom rows of the screen. This line tells you the conditions of the various options and functions, such as upper- or lowercase, carrier detect, full/half duplex, on/off line, operating mode (originate, answer, or automatic), and memory buffer conditions, including on/off, amount used, and amount free. All in all, it is a very friendly program (see photos 4-6).

Unfortunately, without the Com-Ware II program, the Apple-Cat II itself is difficult, if not impossible to

Circle 202 on inquiry card.

Key	Function
<ESC>	Escape. Places you in "Command" mode.
A	Auto-dial. Allows for entry of up to 56 digits and can sense additional dial tones and pauses in 2-second increments. You may also re-dial the last number entered.
B	Print memory. Sends the contents of the 27K-byte buffer to the configured printer port.
C	Terminal CHAT mode. Allows for two-way communication without affecting the buffer contents.
D	Disk command. Allows for the entry of any DOS command, e.g., CATALOG, to allow you to see what data files are on the disk.
F	High-speed Com-Ware transfer. Allows for 1200-bps transfer rate between two Apple-Cat II systems (Bell 202).
H	Hang up. Does just that.
I	Toggle local echo (on/off). Sometimes known as full/half duplex on some terminals, this controls the echoing of characters to the Apple's screen, as opposed to true full/half duplex, which signifies whether there is full two-way simultaneous transfer capability.
K	Keyboard to memory. Allows for direct entry into buffer for later transmission.
L	Load memory from disk. Loads a specified text or binary file from disk into memory.
M	Terminal memory mode. In this mode all keystrokes (transmitted and received) are stored in memory.
N	Serial number. Performs a self-test of the operating software and returns a status message.
P	Pick up phone. Answers incoming voice call and allows for switching from data transmission mode to voice.
Q	End program.
R	Reconfigure terminal/printer. Calls the configuration program.
S	Save memory. Writes buffer contents to disk.
U	Unattended answer/memory on. Gives you an Apple II answering machine (data only).
V	Verify memory. Verifies the contents of the buffer and returns a checksum for comparison.
X	Send memory. Transmits the contents of the buffer.

Table 1: *A list of one-key commands for the Com-Ware II program of the Apple-Cat II.*

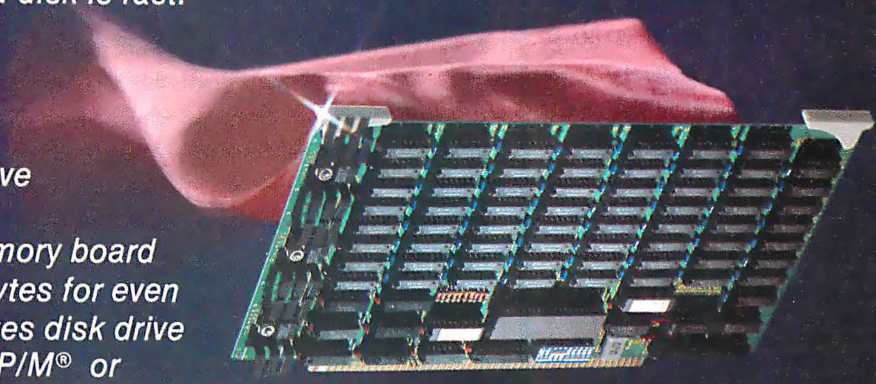
access through BASIC or Pascal. In contrast, other modems, such as those manufactured by Hayes Microcomputer Products, are fairly easy to access, and dozens of programs that take advantage of this have been written. Novation has provided a means for easier access, which I will touch on later.

The RS-232C Port

A 25-pin connector included on the circuit board of the basic system provides access to various auxiliary signals for expanded use of the system. Table 2 describes these pins and explains their uses. One group of these pins comprises an EIA (Electronic Industries Association) standard RS-232C connection. If you use the optional expansion module, these signals, together with those from pins 5 through 14, are brought out to the connectors on the back of the module.

The use of the RS-232C connector is not well documented in the manual. The printer portion of the configuration program refers to a Novation printer port, while the terminal portion of the same program refers to an external port for input/output. These references seem to indicate that you can communicate through an external port rather than the phone line and also access a printer hooked up to an onboard printer port. Well, you can, but not really at the same time—the two ports in question are, in fact, one and the same. The system doesn't care which way you use the port, and it doesn't have a built-in check to see if you have the port configured to be used both ways at once. As you can see, some conflicts could arise.

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Photo 4: *The main menu of Com-Ware II, the Apple-Cat II's terminal program, as shown on the author's screen. The two lines at the bottom form a status display. Commands are entered via a single keystroke. Pressing <ESC> in any mode will return you to this screen.*

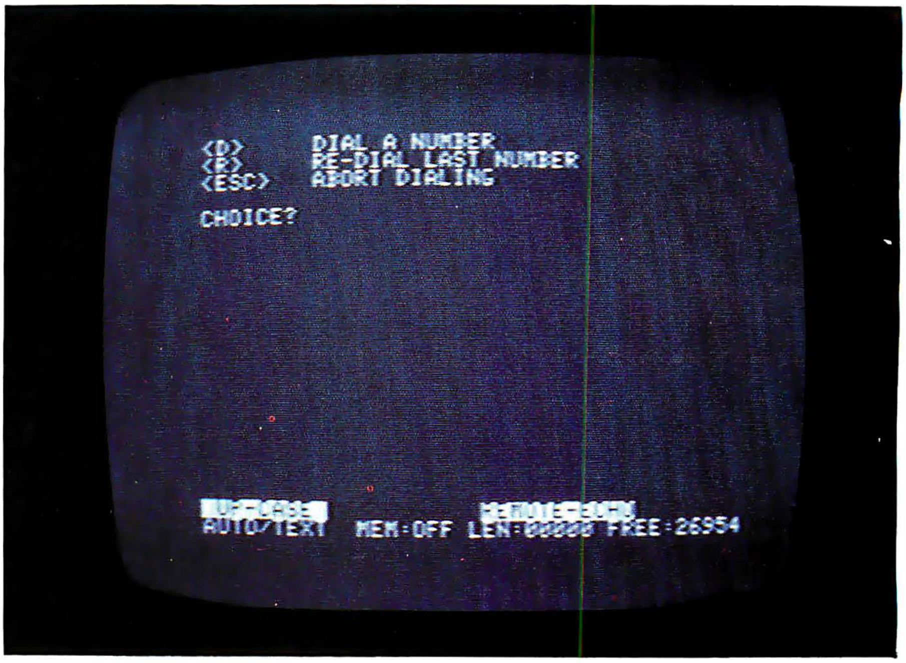


Photo 5: *After typing A in the main menu (photo 4), you get this screen, which shows the auto-dial menu. Pressing R now will redial the last number entered. Pressing D will give you the next screen (photo 6).*

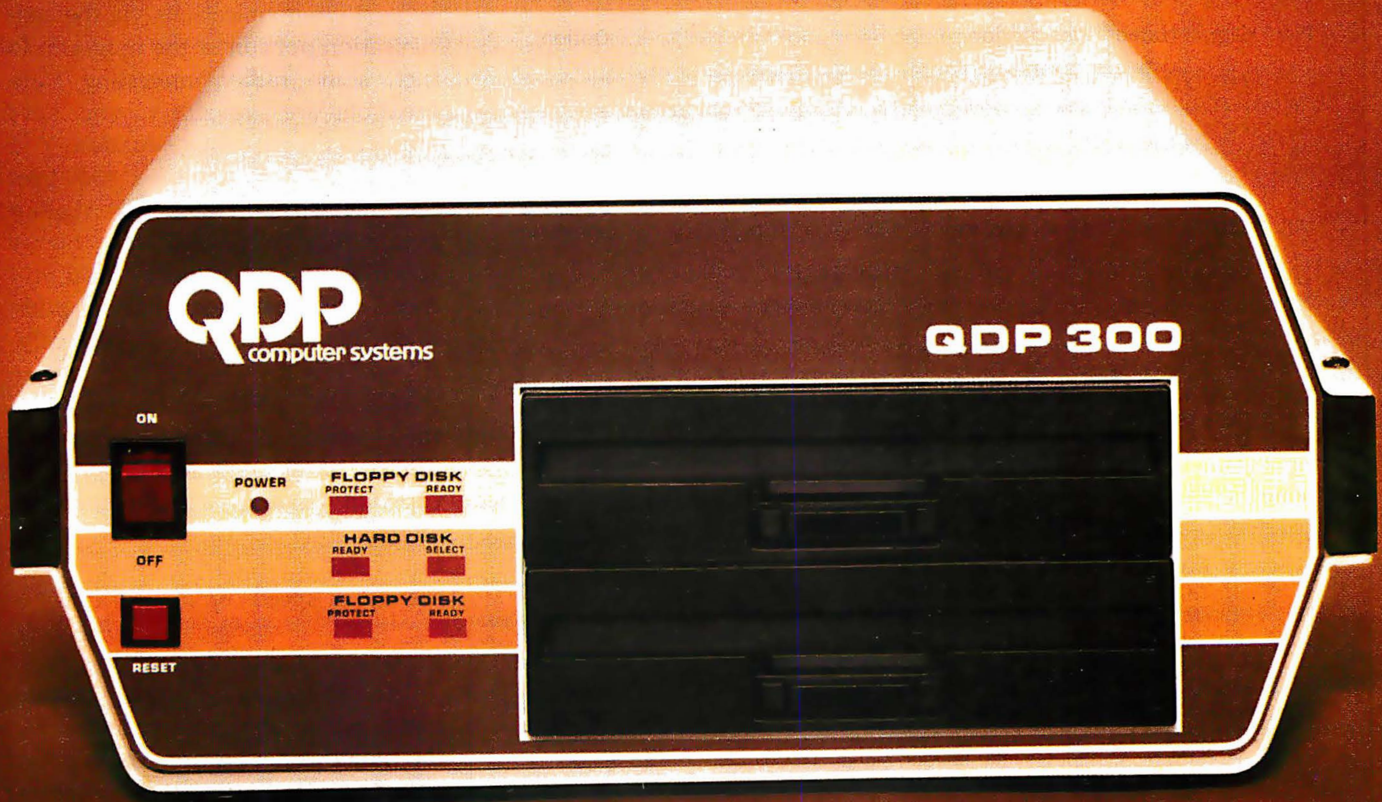
A section on printer characteristics appears in the configuration portion of the Com-Ware II program. This section allows you to choose whether you wish to send printer output to the port or to a card in another slot. You also determine the handshaking method to be used and at what speed you want the port driven, along with the structure of the data (length, parity, and number of stop bits). Because most users who have a printer also have an interface card, this option might not be used very

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Photo 6: *Selecting D from the previous screen (photo 5) gives this entry screen for phone numbers. Note that the options include pauses and waiting periods for a second dial tone. Since the Apple-Cat II can dial using either tone or pulse dialing, it can be used with private branch exchanges (PBX) or long-distance services that require tones, such as MCI. Most other modems do not function in both dialing modes.*

Pin	Signal Name	Description	Option
1	PRT-TXD	output, transmit data	RS-232C
2	PRT-RVD	input, receive data	and
3	PRT-CTS	input, clear to send	printer
4	GND	signal ground	port
5	60Hz	input, AC line reference	BSR X-10
6	GND	signal ground	controller
7	+12V	output, +12 V DC	
9	BSR-SIG	output, 120-KHz control signal	
8	+12V	output, +12 V DC	off-hook
12	OH LED	output, LED drive	LED
10	TAPE 1	output, tape recorder control	tape
11	TAPE 2	output, tape recorder control	recorder
13	AUDIO	output, signal to tape	
14	GND	signal ground	
15	212-RXD	input, receive data	Bell 212
16	212-TXD	output, transmit data	modem
17	212-TXE	output, transmitter enable	card
18	212-CAR	input, carrier detect	
19	212-XMT	input, transmitter signal	
20	GND	signal ground	
21	AUDIO	output, audio, phone line	speech
22	AUDIO	output, audio, phone line	synthe-
23	SPCH-EN	output, speech enable	sizer
24	SPCH-IN	input, synth. speech signal	card
25	GND	signal ground	

Table 2: *This is the pin configuration for the expansion input/output port on the Apple-Cat II board. The Expansion Module plugs into pins 1 through 14; the remaining pins are reserved for future developments.*

often. However, you may want to drive another serial device as if it were a printer, and this option enables you to do that. Once set up, this option can be designated as a default condition if you wish.

If you elect to use the port as a printer port and want to print the contents of the Apple-Cat II buffer, you'll find the commands for doing so are very easy. You merely type B, which causes the contents to be transmitted to the printer via the port. You may stop the transmission by pressing <ESC>. It is as easy as it sounds. (Actually, the command is the same whether you're printing using the built-in port or an interface card in another slot.)

Driving an External Device

This is one of the nicer features of the Apple-Cat II. If you need to communicate with an in-house host and outside sources as well, you can switch from one to the other without undoing a lot of cables or buying another interface card. The Apple-Cat II can be switched from modem to port communications via the configuration portion of the program. In fact, some rather interesting combinations are available to you. Let's consider the following situation: You need to use both low-speed (300 bps) and high-speed (1200 bps) dial-up communications, and the higher speed uses Racal-Vadic VA3400 protocol, which means you have an additional modem to drive occasionally. If you hook the VA3400 modem into the RS-232C port, you can configure the system to drive the external modem whenever necessary. This capability saves you the need for another interface card and gives you buffer and auto-dial capabilities with the higher-speed communications.

Expansion Capabilities

The following optional attachments will probably be available by the time this review appears in print:

- a Bell 212 protocol card that will allow you to transmit data at 1200 bps in full-duplex mode
- a separate BSR X-10 controller unit that will plug into the Expansion

Module and allow you to control BSR remote units without using a BSR Command Console

- a Touch-Tone decoder chip that, when plugged into the basic circuit board, will allow the system to decode Touch-Tone codes (from a remote phone, for example)
- a firmware ROM chip that will easily allow specialized applications

Other options that are still under development include a tape recorder output that would allow you to record Apple-Cat II transactions and a speech synthesizer card that would enable the Apple-Cat to "speak."

As mentioned before, one of the most frustrating aspects of the Apple-Cat II is the inability to access it directly from BASIC, Pascal, or by any other way than via the provided software or special software packages. Novation has just recently developed an EPROM that will allow you to access the Apple-Cat II from the BASIC environment. This EPROM will feature commands that are compatible with the Hayes Micromodem II. However, only those programs for the Micromodem II that are written in BASIC will function, as the two units are accessed differently in the 6502's assembly-language environment.

Conclusions

You might have gotten the impression at the beginning of this article that I was disappointed about the features Novation or its dealers were pushing to market the basic Apple-Cat II unit. I still am. While I feel that Novation should flaunt its accomplishments, I feel even more strongly that the company's literature should be very explicit about the unit's present capabilities and future developments. After all, we, the professional hackers of the microcomputer world, are going to use these products in many ways—including some that Novation never imagined. I feel that it is only fitting that we be given accurate information as to just how far the manufacturer has gone and where it plans to go from here.

I would feel much better if I had found an insert in the manual saying, "This manual has been written with a fully developed system in mind. As of this date, xx/xx/xx, the following areas have been finished: A, B, C, etc. Future developments are. . . ." After all, we pay for the product, and keeping us informed would show a lot of goodwill.

As for the future of the Apple-Cat II, it's clear that Novation has the best combination going in the field of Apple II communications. My advice to current modem owners (Hayes and others) is to watch the developments and weigh the advantages of switching. If you don't, you may find yourself left behind. Apple users shopping for a modem would be wise to consider this system very carefully if they even contemplate using the Apple II as something other than a dumb terminal. ■



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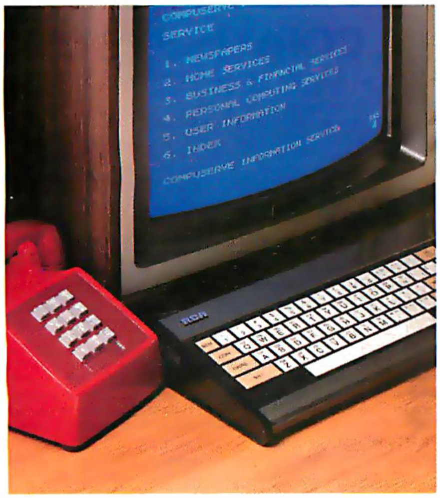
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Math/Graphmagic Combo	NEW!	$ 160	$109
LEXISOFT, Spellbinder (a versatile WPS in CP/M-86)		$ 495	$249
★ MICROCRAFT, Requires CP/M-86 & CBASIC-86			
Legal Billing & Time Billkeeping		$ 750	$395
Professional Billing & Time Keeping — Billkeeper		$ 750	$395
★ MICRO LAB, The Tax Manager		$ 250	$189
★ MICROPRO, WordStar® plus free WordStar Training Manual		$ 495	$249
MailMerge™		$ 250	$ 79
SpellStar™		$ 250	$129
3 Pak, Word & Mail & Spell, above 3		$ 845	$445
MICROSOFT, FLight Simulator (by Sub-Logic)	NEW!	$ 50	$ 35
NORELL, Visualize		$ 100	$ 75
Easy Data DBMS		$ 250	$189
NORTH AMERICAN BUS. SYSTEM, The Answer		$ 250	$169
PBL CORPORATION, Personal Investor	NEW!	$ 145	$ 99
★ PEACHTREE, Peach Pak 4 (GL, AR & AP)		$ 595	$395
PERFECT SOFTWARE, Perfect Writer™		$ 389	$239
Perfect Speller™		$ 189	$119
Perfect Filer™		$ 289	$179
SELECT INFO, Select (a WPS)		$ 595	$339
SORCIM/ISA, SuperCalc		$ 295	$199
SuperWriter		$ 395	$269
SYNERGISTIC, Data Reporter	NEW!	$ 250	$169
★ VISICORP, VisiCalc®/256K		$ 250	$179
VisiDex		$ 250	$199
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VisiFile		$ 300	$239
Desktop Plan 1		$ 300	$239
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NAGY SYSTEM, Copy/PC, Backup Copier and Utilities		$ 35	$ 29
NORELL DATA, System Backup, Bit Copier		$ 50	$ 39
NORTON, Norton Utilities, 14 powerful programs, 3 disks		$ 80	$ 65

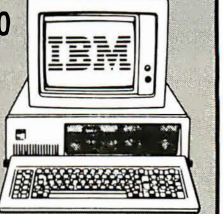
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Zork II		$ 40	$ 29
Zork III	NEW!	$ 40	$ 29
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System Includes
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Combo Plus, 64K with parallel port.	$ 495	$359
Combo Plus, 64K w/async. & para.	$ 555	$395
Combo Plus, 64K w/async. para. & clock/cal.	$ 595	$429
For above Combo Plus of 128K add $85, for 192K add $192, for 256K add $256.		
Parity Memory w/SuperDrive, 64K	$ 395	$265
128K	$ 535	$349
192K	$ 675	$435
256K	$ 795	$495
CORVUS, Hard Disk System		Call
CURTIS, PC Pedestal,™ for Display on PC	$ 80	$ 65
9 Foot Cable for IBM Mono Display (extends 3' to 9')	$ 50	$ 45
DAVONG DSI 501 Hard Disk, 5 Meg	$1995	$1495
MICROSOFT 64K RAM Card w/Parity	$ 350	$259
128K RAM Card w/Parity	$ 525	$395
256K RAM Card w/Parity	$ 875	$659
64K RAM Chips™	$ 175	$129
Tecmar Inc. ALLinONE Board, 64K	$ 565	$415
128K	$ 735	$535
256K	$ 975	$675
QUADRAM CORPORATION		
Quadboard, 64K, expandable to 256K, 4 function board	$ 595	$435
Quadboard, 128K, expandable to 256K, 4 function board	$ 775	$565
Quadboard, 192K, expandable to 256K, 4 function board	$ 895	$635
★ Quadboard, 256K, four function board	$ 995	$670
Memory Board, 512K, with Serial Port, #6512	$1295	$995
Memory Upgrade Kit, 64K (9 chips), #B260	$ 150	$ 95
Microlazer, Snap-on, 8K, Par/Par, Epson, #MEB, w/PSI	$ 159	$145
Microlazer, Snap-on, 64K, Par/Par, Epson, #ME64, w/PSI	$ 299	$235
Power Supply for Microlazer, (9V, 25A), #PSI	$ 20	$ 15
TG PRODUCTS, Joystick	$ 65	$ 49
Tandon TM100-2 Double Sided 320K, 1 ea.	$ 350	$259
★ 2 or more	$ 350	$249

Same Disk Drives as now supplied on IBM-PC.

★ XEDEX **Baby Blue** 64K plus CP/M-80 operation	$ 600	$449

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Gemini 15	$ 649	$495
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IDS, Microprism 480, near letter quality, 110cps, 80 col.	$ 799	$699
Prism 80 Color, 200cps (all options-color, sprint, auto)	$1795	$1450
★ Paper Tiger, 440 w/Graphics and 2K. Limited Special	$1295	$495
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★ OLYMPIA, ES-100, Printer/Typewriter, complete with all interfacing to the Apple II	$1735	$1295
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Comriter Tractor Feed for CR-I	$ 118	$ 99

SUPPLIES: Tractor Feed Paper, Ribbons, Heads, Qume Daisy Wheels & Ribbons.

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IBM-PC to Epson Cable	$ 60	$ 45
Apple Interface and Cable for MX80 or MX100	$ 120	$ 95
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IBM, 10 each, 5¼, SS, SD (Apple, IBM, etc.)	$ 60	$ 45
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10 each, 5, DS, DD	$ 65	$ 49

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COMSHARE TARGET, Target PlannerCalc		$ 99	$ 39
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PlannerCalc Applications Pkg.		$ 50	$ 40
PlannerCalc Combo Pkg.		$ 125	$ 65
INFOCOM, Deadline		$ 60	$ 45
Zork I		$ 50	$ 39
Zork II		$ 50	$ 39
Zork III	NEW!	$ 50	$ 39
Starcross	NEW!	$ 50	$ 39
ISM, MatheMagic		$ 100	$ 75
MICROCRAFT, Legal Billing & Time Keeping		$ 750	$395
Prof. Billing & Time Keeping — Billkeeper		$ 750	$395
★ MICROPRO, WordStar® plus free WordStar Training Manual		$ 495	$249
MailMerge™		$ 250	$ 79
SpellStar™		$ 250	$129
3 Pak, Word & Mail & Spell, 3 above		$ 845	$395
SuperSort		$ 250	$169
DataStar		$ 295	$199
CalcStar		$ 145	$ 99
MICROSOFT Multiplan		$ 275	$199
Fortran 80		$ 500	$325
BASIC Compiler		$ 395	$295
COBOL-80		$ 750	$545
BASIC-80		$ 350	$275
muLisp/muStar-80		$ 200	$145
M-Sort-80		$ 195	$145
Edit-80		$ 120	$ 80
Macro-80		$ 200	$145
OASIS, The Word Plus (45,000 word verification)		$ 150	Call
PEACHTREE, Magic Wand		$ 500	$195
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Series 8 GL, AR, AP, Inv. or Pay, each		$ 750	$495
Series 9 Peach Text		$ 500	$330
Series 9 Spelling Proofreader		$ 300	$195
Series 9 Calc. Mail List or Telecomm., each		$ 375	$245
PERFECT SOFTWARE, Perfect Writer™		$ 389	$239
Perfect Speller™		$ 189	$119
Perfect Filer™		$ 289	$179
SELECT INFO., Select (a WPS)		$ 595	$359

MONITORS

NEC, 12" Green		$ 249	$159
12" Color, Composite		$ 450	$349
SANYO, 9" B&W		$ 190	$149
9" Green		$ 200	$139
★ 12" B&W	Special Truckload Sale	$ 250	$139
12" Green		$ 260	$199
13" Color, Composite		$ 470	$349
13" Color RGB		$ 995	$795
ZENITH, 12" Green		$ 150	$119
AMDEK, 12" Green #300		$ 200	$159
13" Color I, Composite		$ 449	$359
13" Color II, RGB, Hi Res. (Ap. II, III & IBM-PC)		$ 899	$799
13" Color III, RGB, Commercial, (Ap. II, III)		$ 569	$469
DVM, Color II or III to Apple II Interface		$ 199	$175

Note: Color II and III come with cable for IBM-PC.

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HAYES, Micromodem II (for the Apple II)	$ 379	$275
Apple Terminal Program for Micromodem II	$ 99	$ 69
NOVATION, Applecat II Modem	$ 389	$269
212 Apple Cat	$ 725	$599
HAYES, Stock Chronograph (RS-232)	$ 249	$189
Stock Smartmodem (RS-232)	$ 289	$225
Smartmodem 1200 (RS-232)	$ 699	$535
Micromodem 100 (S-100 bus)	$ 399	$275
SIGNALMAN, Modem MKI (RS-232)	$ 99	$ 79
IBM-PC to Modem Cable	$ 39	$ 29
AXLON, Datalink 1000HandHeldCommunicationsTerminal	$ 399	$325

★★ CORVUS SYSTEMS

★ 6 Meg Hard Disk, w/o interface	$2995	$2095
★ 11 Meg Hard Disk, w/o interface	$4795	$2695
★ 20 Meg Hard Disk, w/o interface	$5795	$3495
IBM PC Interface (IBM DOS), Manual & Cable 5	$ 300	$239
Mirror built in for easy backup	$ 790	$595
Apple Interface, Manual & Cable 5	$ 300	$239

Other Interfaces, Omni-Net, Constellation, Mirror. All in Stock.

hp		
H/P 7470A Graphics Plotter	$1550	$1195
H/P 41C Calculator	$ 195	$169
H/P 41CV Calculator with 2.2K Memory	$ 275	$239

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64K (48K + COEX 16K)	$1725	$1150
Disk, MicroSci A2 w/3.3 Controller	$579	$378
Disk, Micro Sci A2 Only	$479	$299



The B&H Apple II+ differs from the Apple Apple II+ only in that it is in black hammertone color and its warranty is longer.
Warranty: Factory warranty is by Bell and Howell (not by Apple) and is one year parts plus 90 day labor. Warranty service available at Bell and Howell service centers or return to Computer Exchange.

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- Game Paddles
- Game with Color Graphics and Sound

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Micro-Sci A2 drives and/or controllers are direct plug compatible substitutes for Apple drives and controllers.

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● For Apple II		
A2, 5¼", 143K Disk Drive	$ 479	$299
Controller Card for A2 Drive	$ 100	$ 79
A40, 5¼", 160K Disk Drive	$ 449	$359
A70, 5¼", 286K Disk Drive	$ 599	$479
Controller for A40 or A70	$ 100	$ 79
Filer, Disk Utility Software	$ 20	$ 15

HARDWARE
for Apple II/II+

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RAM EXPANSION:			
★ COEX RAM Card	16K	$ 179	$ 59
★ ALS, ADDRam	16K	$ 149	$ 79
★ Microsoft, RAMCard	16K	$ 195	$ 89
★ Saturn Systems,	32K	$ 249	$169
	64K	$ 425	$319
★ Axlon	128K	$ 475	$375
★ Axlon, RAM Disk	320K	$1395	$995
80 COLUMN VIDEO CARDS:			
★ ALS, Smarterm		$ 345	$249
Videx, Videoterm		$ 345	$239
Vista, Vision 80		$ 395	$199
MISCELLANEOUS:			
ALS, Smarterm 80 Col. Card	Special	$ 345	$249
Z Card (Z-80) W/CPM	Special	$ 269	$199
★ 16K ADDRam	Special	$ 149	$ 79
Synergizer w/S'calc + Condor		$ 749	$529
Axlon, 320K RAM Disk System		$1395	$995
ASTAR, RF Modulator		$ 35	$ 25
CCS, Serial Interface 7710A		$ 150	$129
Other CCS Cards in stock		Call	Call
Dan Paymar, Lower Case Chips		$ 50	$ 39
Don't Ask, DAO-003 S.A. Mouth		$ 125	$ 85
Kensington, System Saver		$ 90	$ 69
Kraft, Joystick		$ 65	$ 49
Paddle		$ 50	$ 39
M&R, Sup R fan		$ 50	$ 39
★ Microsoft, Z80 Softcard Pack		$ 345	$245
★ Softcard Premium Pack		$ 695	$495
★ 16K RAMCard		$ 100	$ 89
Mountain, CPS Multifunction Card		$ 239	$199
Orange Micro, Grappler Plus		$ 165	$119
Practical Peripherals,			
MBS 8K Serial (Epson)		$ 159	$129
MBP 16K Para (Epson)		$ 159	$129
Microbuffer II 16K, (specify)		$ 259	$209
Microbuffer II 32K, (specify)		$ 299	$229
★ PCPI, Appli-Card, 14 features.			
	4 Mhz	$ 445	$325
	6 Mhz	$ 595	$435
RH Electronics, Super Fan II		$ 75	$ 59
SSM, A10-11, Serial/Para. Interface		$ 225	$169
TG Products, Game Paddles		$ 40	$ 29
Joystick		$ 60	$ 45
Select-A-Port		$ 60	$ 45
Versa, VersaWriting			
Graphics Tablet		$ 300	$239
★ Videx, Videoterm 80 col.		$ 345	$249
Soft Video Switch		$ 35	$ 25
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Full Videx Line. Call. Up to 35% off.			
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8001 32K Computer	$ 995	$699
286K Total, Dual Drive PC8031	$ 995	$699
32K addon and I/O Unit PC8012	$ 649	$485

Call for other software and accessories.

SOFTWARE
on disk for Apple II/II+

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Apple Writer II	$ 150	$119
Apple Pascal	$ 250	$199
Apple Fortran	$ 200	$159
DOS Tool Kit	$ 75	$ 59
DOS 3.3 Upgrade Kit	$ 75	$ 59
Apple Pilot	$ 150	$119
DJ Portfolio Evaluator	$ 50	$ 45
How to!	$ 50	$ 25
Microcourier	$ 250	$125
Micro Telegram	$ 250	$125
Apple Logo	$ 175	$149
Applied Soft Tech., VersaForm	$ 389	$265
Artsci, MagicWindow II New!	$ 150	$ 99
Ashion-tate, dBase II (CP/M)	$ 700	$439
Continental, GL, AR, AP or PR. ea.	$ 250	$169
1st Class Mail	$ 75	$ 49
Home Accountant	$ 75	$ 49
Hayden, Pie Writer (Specify brd.)	$ 170	$ 99
★ High Tech., Job Control Sys.	$ 750	$350
Info Master	$ 189	$119
Howard Soft,		
Real Estate Analyzer II	$ 195	$129
Tax Preparer	$ 150	$ 99
Info. Unlim., Easywriter (PRO)	$ 175	$119
★ ISA, Spellguard (CP/M)	$ 295	$ 99
LJK, Letter Perfect w/Mail Merge	$ 150	$ 99
★ Micro Craft, (CP/M)		
Professional Billkeeper	$ 750	$395
Legal Billing & Timekeeping	$ 750	$395
Micro Lab, Invoice Factory	$ 200	$ 99
Tax Manager	$ 150	$ 99
Micro Pro, (all CP/M)		
WordStar® + Training Manual	$ 495	$199
MailMerge T.M.	$ 250	$ 69
SpellStar T.M.	$ 250	$ 99
SPECIAL! All 3 above	$ 895	$349
Data Star T.M.	$ 295	$149
★ Microsoft, Multi-Plan (CP/M)	$ 275	$175
Multi-Plan (DOS 3.3) New!	$ 275	$175
Muse, Super Text 40/80	$ 175	$129
Super Text 40/56/70 New!	$ 125	$ 95
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The Dictionary New!	$ 100	$ 69
General Manager II New!	$ 230	$155
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★ Practical Basic Programs 40 more very valuable programs beyond "Some Com BasicProg"	$ 100	$ 49
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Series 40 GL, AR or AP, each	$ 400	$275
Series 40 GL & AR & AP, all 3	$ 595	$395
Series 40 Inv. or Pay., ea.	$ 400	$275
Series 9 Text & Spell & Mail, all 3	$ 595	$395
Series 80 GL & AR & AP, Videx	$ 595	$395
Perfect, Perfect Writer	$ 389	$239
Perfect Speller	$ 189	$119
Perfect Filer	$ 289	$179
Quality, GBS w/3 gen. (a DBMS)	$ 650	$475
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Sof./Sys., Executive Secretary	$ 250	$169
Executive Speller	$ 75	$ 55
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★ Stockfile	$ 600	$350
Stockseller	$ 700	$450
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Acctg. Plus, GL, AP and A/R	$ 995	$595
Acctg. Plus, above + Inventory	$1395	$775
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PFS II	$ 125	$ 85
Report	$ 95	$ 65
Graph	$ 125	$ 85
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Stoneware, DB Master	$ 229	$155
DB Utility I or II	$ 99	$ 69
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Applewriter II preboot disk	$ 20	$ 15
Visicalc to 64K preboot disk	$ 50	$ 39
Viscalc to 176K preboot disk	$ 90	$ 69
VisiCorp/Personal Software,		
Visicalc 3.3	$ 250	$179
VisiDex Special!	$ 250	$150
VisiFile	$ 250	$179
Desktop Plan II	$ 250	$179
Desktop Plan III	$ 300	$219
Visiplot	$ 200	$149
VisiSchedule New!	$ 300	$219
VisiTrend & VisiPlot	$ 300	$219
VisiTerm	$ 100	$ 79

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DOS Boss	$ 24	$ 18
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Filer, DOS Utility	$ 20	$ 15
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Epson, Graphics Dump	$ 15	$ 9
Insoft,		
GraFORTH by Paul Lutus	$ 75	$ 59
TransFORTH II by Paul Lutus	$ 125	$ 99
Microsoft,		
A.L.D.S.	$ 125	$ 75
BASIC Compiler	$ 395	$299
Cobol 80	$ 750	$559
Fortran 80	$ 195	$149
TASC Compiler	$ 175	$159
★ Omega, Locksmith (bit copier)	$ 100	$ 75
Penguin, Comp. GraphicsSys. New!	$ 70	$ 53
Graphics Magician New!	$ 60	$ 41
Phoenix, Zoom Grafix	$ 40	$ 29
Quality, Bag of Tricks New!	$ 40	$ 29
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ALS 16K AddRAM Card	$ 149	$ 79
Microsoft 16K RAMCard	$ 195	$ 89
Saturn Systems, 32K RAM Card	$ 249	$169
ALS ZCard, Z80 CP/M Card	$ 269	$199
ALS Smarterm 80 Col. Card	$ 345	$249
ALS Synergizer Pack, 3 above plus Supercalc plus Condor Jr.	$ 749	$529
Videx Videoterm, 80 column card	$ 345	$239

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Arcade Machine	$ 45	$ 40
Choplifter New!	$ 35	$ 26
Many others		Call
Budgeco, Raster Blaster	$ 29	$ 22
Continental, Home Accountant	$ 75	$ 49
Datamost, Snack Attack	$ 30	$ 24
Datasoft, Canyon Climber New!	$ 30	$ 23
Edu-Ware, Several in stock	Call	Call
Auto. Simulations,		
Introductory 3-Pack	$ 50	$ 35
Hayden, Sargon II (Chess)	$ 35	$ 29
Infocom, Deadline	$ 50	$ 38
Insoft, Electric Duet by Lutus	$ 30	$ 25
Zargs New!	$ 35	$ 27
Spider Raid New!	$ 30	$ 24
Lightning, Mastertype	$ 40	$ 29
Microsoft, Olympic Decathlon	$ 30	$ 24
Typing Tutor II	$ 25	$ 15
Muse, Robot War	$ 40	$ 29
Castle Wolfenstein	$ 30	$ 23
On-Line, Frogger New!	$ 35	$ 25
Ultima II	$ 55	$ 40
Softporn (X Rated)	$ 30	$ 22
Piccadilly, Warp Destroyer	$ 30	$ 23
Sirius, Gorgon	$ 40	$ 29
Sir-Tec, Wizardry	$ 50	$ 39
Knight of Diamonds. New!	$ 35	$ 26
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Pinball	$ 30	$ 23
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810 Disk Drive	$ 600	$499
850 Interface	$ 220	$169
410 Recorder	$ 100	$ 79
Axlon,		
★ Rampower 128K System (for 800)	$ 475	$350
Rampower 48K Module (for 400)	$ 185	$135
★ Rampwr. 32K Module (400 or 800)	$ 120	$ 89

Free with above 3: Ramscan, Diagnostic Diskette.
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The Next Generation of Microprocessor

A proposed inexpensive microprocessor that can directly execute a high-level language.

Timothy Stryker
Samurai Software
POB 2902
Pompano Beach, FL 33062

It will not be long before integrated-circuit manufacturers begin to come out with single-chip processors that can directly execute high-level-language instructions. When this happens, the resulting explosion in the availability of high-speed, high-quality software could make the present stage of the computer revolution look like a halfhearted warm-up exercise by comparison.

The reason for this is very simple: it is far more convenient to develop software in high-level languages than it is in the assembly languages that are currently available. This convenience factor has meant that most custom-designed software has been written in high-level languages, even though, under current microprocessor architectures, an enormous penalty in terms of performance is typically paid. One commonly hears statements that an assembly-language program will run a hundred times faster than the equivalent program written in BASIC. The only reason that most programs continue to be written in BASIC is that it is perhaps a hundred times easier to do so. Although compilers are available that can boost high-level-language performance, they are costly and require the use of large, expensive computers. And even a compiled program may be 10 times slower than an assembly-language program. An inexpensive processor whose assembly language was itself a high-level language would gain wide market acceptance virtually overnight. IC manufacturers are naturally aware of this, and concrete evidence of this awareness (i.e., an actual chip) can be expected soon.

An inexpensive processor whose assembly language was itself a high-level language would gain wide market acceptance virtually overnight.

No doubt a fair amount of confusion exists at present as to just how to go about the implementation of a high-level language in hardware. National Semiconductor and Zilog have each introduced single-chip microcomputers incorporating small BASIC interpreters in on-chip ROM (read-only memory). While this is a step in the right direction, the utility of these chips is greatly diminished by their slow processing speeds. The low-level architectures of both chips are entirely conventional in nature, and the fact that they happen to incorporate BASIC on-chip rather than in an external ROM represents merely an advantage in terms of decreasing system chip count. Higher up on the scale are Western Digital's Pascal and Ada Microengines, multichip processors that have experienced only limited market acceptance due to their high costs. The Intel iAPX-432 processor appears to be a promising development in this area, but the great complexity of its architecture would appear to put it out of the sights of most potential users for the time being.

Another much-discussed approach

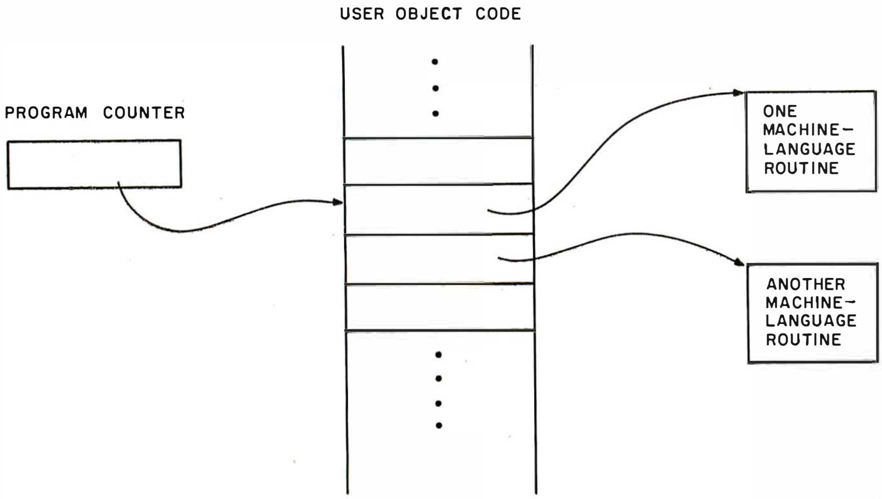


Figure 1: *Simple threaded object code. The program counter points to certain object code, which in turn points to a machine-language routine. When that routine is finished, the program counter is incremented and points to the next object code, which points to the next machine-language routine.*

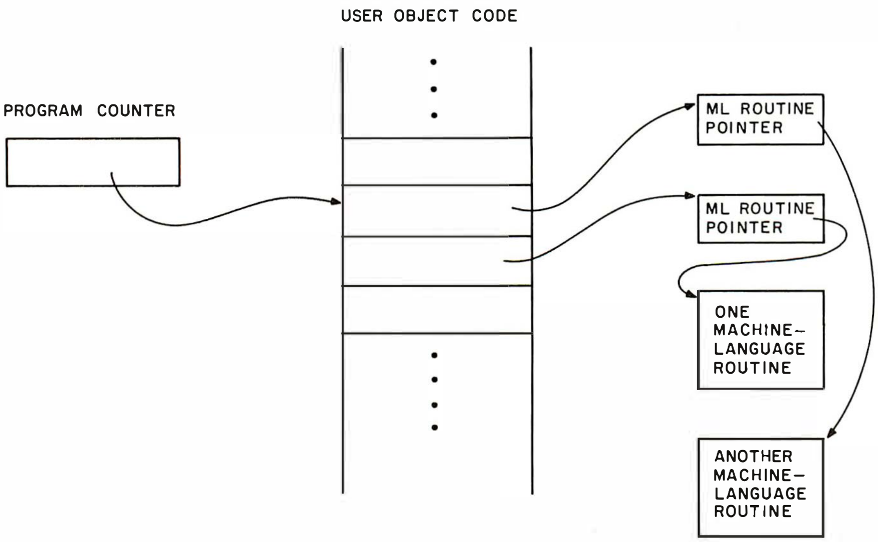


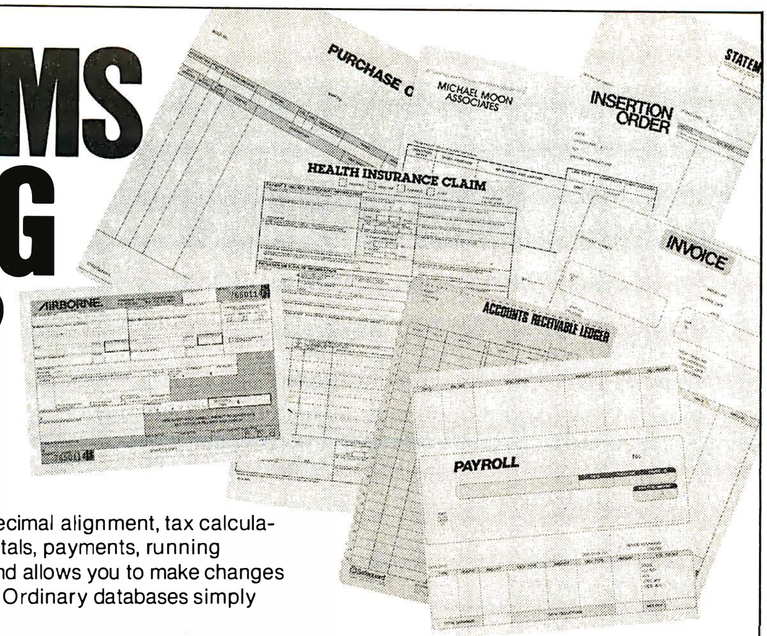
Figure 2: *Threaded object code, FORTH style. In FORTH the object code points not to a machine-language routine, but to another pointer, which then points to the routine. If the routines are short, more time is spent jumping to the routines than executing them.*

to the question has centered around the prospects for a FORTH machine. FORTH would appear at first to be the perfect candidate for implementation in hardware because of its reverse Polish syntax and its inherently stack-oriented nature. The reason that these factors single FORTH out as a prime candidate for hardware implementation is that other types of high-level languages must invariably translate user requests for expression evaluation into stack-oriented terms at some level. In order for a high-level language to appear as the true, one-for-one, assembly-level equivalent of machine language, it is almost a necessity that the high-level language itself be stack-oriented. FORTH is the only well-known stack-oriented high-level language; hence, FORTH comes to mind as a major contender for hardware implementation.

A more detailed examination of the structure of FORTH may, however, help explain why the implementation of this language in hardware has not gained wide support. FORTH was conceived as an inherently threaded language. This means that its object code, unlike that of most compiled languages, is set up as a series of pointers, rather than as directly executable machine code. In principle, a threaded language could be designed in which these pointers directly indicated executable machine-language routines (see figure 1). FORTH, however, is set up so that the pointers indicate other pointers, which, in turn, point to the executable machine-language routines (see figure 2). The way in which FORTH transfers control from one machine-language routine to the next is by having each machine-language routine terminate in a JUMP to a routine called NEXT. This routine increments FORTH's "program counter" to address the next object-code pointer in sequence. Control is then passed by another sequence of pointers (or a double-indirect JUMP) to the next machine-language routine desired.

This double-indirect control-transfer process is all very fine as long as the number of machine cycles required to accomplish the effect of a typical FORTH operator is large in comparison to the number required for the double-indirect JUMP itself. In designing a processor with a stack-oriented architecture, however, one would certainly intend to create single-byte op codes like ADD and SUBTRACT, whose function would be to accomplish, in very few cycles, the addition or subtraction of the top two stack entries to or from one another. Under these circumstances, the number of machine cycles required for getting *to* the op codes in question, via the double-indirect JUMP, could be substantially greater than the number required to do the operations themselves. This observation applies even if the machine's instruction set were to incorporate a 1-byte NEXT instruction that could be placed at the end of each machine-language routine instead of a JUMP to a whole NEXT routine. Thus, it would appear that, paradoxically, the

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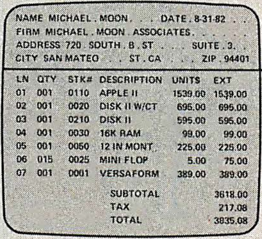
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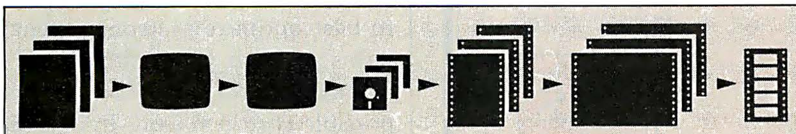
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very object structure attributes that make FORTH nearly ideal for non-stack-oriented hardware make it relatively ill-suited for use as the basis of a true stack-oriented machine.

An Alternative

The primary disadvantage of using FORTH as the basis for the hardware implementation of a high-level language is, as discussed, its threaded nature. I would like to present an alternative scheme that skirts these difficulties and that represents a viable, cost-effective approach to the implementation of a high-level language in hardware. This scheme is the result of more than three years of extensive commercial refinement and testing in such applications as real-time industrial process control, compiler development, and database analysis.

One of the first things to be established in the design of any new processor is the range of intended applications that the processor should address—in commercial terms, its intended market. The market segment that is ripe for exploration at this point is the small, inexpensive, but largely custom-programmed, software-intensive system for which speed of development and speed of data manipulation must go hand in hand. For systems of this type, 16-bit data-handling and 16- to 24-bit addressing capabilities should be sufficient for the next several years. Of primary importance is that the costs associated with both hardware and software development in systems of this type should be minimized.

If we agree that software development costs are best minimized through the implementation of a stack-oriented high-level language as the assembly language of the machine, the design problem then revolves around the question of how to best optimize system efficiency in terms of both processing speed and memory-space usage, at the lowest possible cost in silicon. In optimizing the design of the system for processing speed and memory-space usage, we must consider the typical uses to which the system will be put—in particular, we must ask three questions:

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- What operations are necessary in order to provide the minimum level of power consistent with the user's need for high-level-language capabilities?
- What additional operations would be desirable, and how does the cost of their inclusion compare with the software development costs that would be incurred by leaving them out?
- What will the relative frequencies of occurrence of each of these operations be in terms of both time and space in typical user programs?

In answer to the first question, most people would agree that the operations considered vital would include the following:

- 16-bit numeric push and pop
- top-of-stack duplicate and top-pair swap
- 16-bit two's-complement addition and subtraction
- 16-bit Boolean AND, OR, and NOT operations
- 16-bit comparison operations (greater-than, less-than, and equals), and some means for using the results of comparisons to control program flow (if-then)
- subroutine call and return
- 16-bit memory-fetch and memory-store
- GOTO (all structured programming ballyhoo to the contrary)

Note that we do not have to concern ourselves here with any questions as to addressing modes. The stack-orientation of the language takes care of all that automatically. For example, the memory-fetch operation would be expected to replace the top stack entry with the contents of the memory location originally addressed by that stack entry. To do an indirect fetch then, one would simply perform two ordinary memory-fetch operations in a row. To do an indexed fetch, one would merely get the base address and the index into the top two positions on the stack, perform an addition, and then perform a normal memory-fetch. Other addressing modes of arbitrary complexity, such as triple-indirect and doubly indexed-indirect, can be similarly formulated simply by using the basic operations as building blocks. This synergy is a function of the beautiful simplicity and cleanliness of the stack-oriented approach. We can achieve a fully symmetrical, easy-to-learn instruction set of enormous power without spending a fortune on silicon.

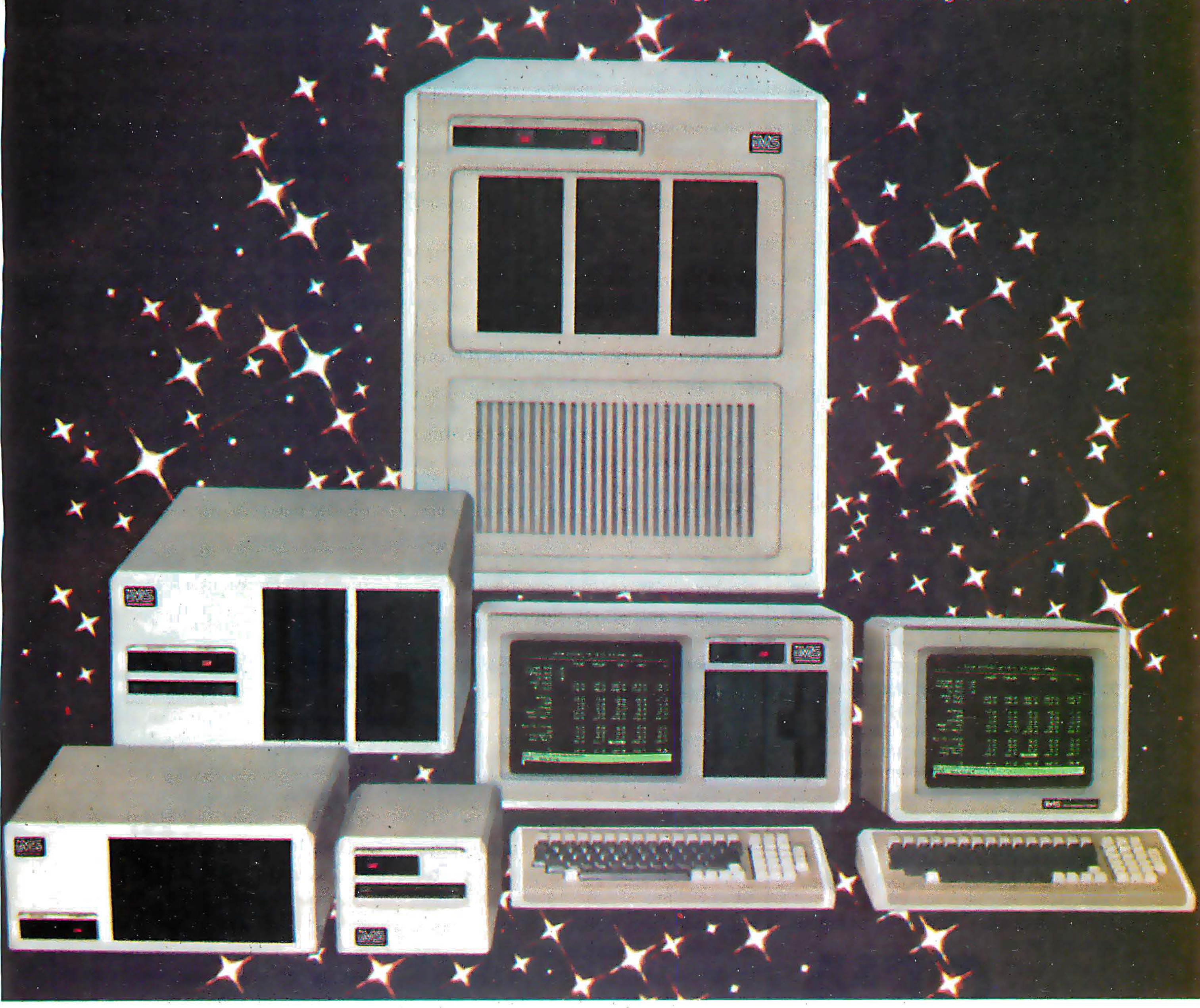
One is tempted at this point to begin wondering just how the various capabilities listed above would be made available to the user, how they would be implemented in the hardware, and so on. Let us leave these questions aside for the moment until we have had a chance to address the last two questions raised earlier. The above collection of operations would appear to represent the true bare-bones minimum needed. What else would it be desirable for the architecture to support in the form of hardware primitives?

Here we enter into a realm of speculation in which there is con-

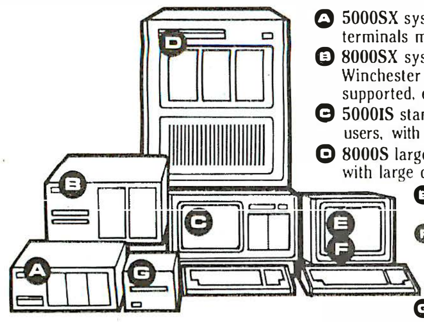
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siderable room for disagreement. Each individual has a different idea as to what constitutes the ideal mix of hardware capabilities, and we find little in the way of objective criteria to go on, because the whole field of stack-oriented high-level-language development is still in its infancy. For this reason, actual working experience with such languages is invaluable. It is only by having used a stack-oriented language extensively that one can get a feel for what features are particularly desirable and what features are not. As noted above, I have been experimenting with these languages for more than three years now, and my personal experience is reasonably representative of many of the kinds of applications in which a processor such as the one discussed here would be used.

Turning first to the question of additional arithmetic operations, multiplication and division arise as prime candidates for inclusion. I have found considerable use for both, even in connection with entirely logic-based tasks. Multiplication is of particular use in multidimensional array indexing and singly dimensioned array indexing in cases where the array element size is not a power of 2. The need for division crops up somewhat less frequently, but it and its corollary, the modulo operation, are sufficiently time-consuming (in both development and execution time) for a programmer to implement in software that it is a real blessing to have them available as language primitives. Thus, full 16-bit unsigned multiplication (with a 16-bit result), division, and modulo are all included in the architecture presented here.

Right-shift and left-shift operations are commonly found in current assembly languages for good reason, and we would hope to have them available here as well. Left-shift, synergistically enough, can already be accomplished very easily using the top-of-stack-duplicate and addition functions. Right-shift cannot. I would propose to rectify this, not by supplying a right-shift operator, but by designing the division hardware such that if division by a power of 2 is called for, the operation will be carried out as a simple right-shift of the appropriate number of bit-positions. This arrangement has the additional benefit that ordinary divisions need take no longer to execute than the minimum amount of time, even in cases where the programmer does not know in advance whether or not the divisor in the computation will be a power of 2.

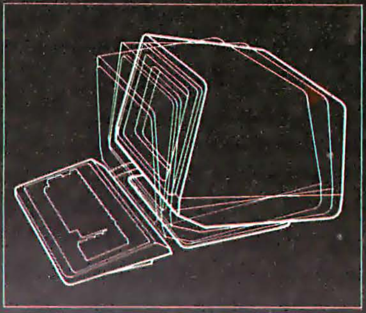
The exclusive-OR or XOR operation is the only Boolean operation conspicuously missing from the above list. It is infrequently needed, but to derive it using the other operators is comparatively time-consuming. One possibility would be to design the equals function as a bitwise exclusive-NOR. This, however, while intriguing, would lead to problems in other areas. Given that XOR is not particularly costly to implement in hardware, it should be included as a hardware primitive.

In writing programs in a stack-oriented language, one constantly finds the need for stack-manipulation operators more powerful than the simple top-of-stack-duplicate (let's call this DUP, as FORTH does) and top-pair-swap (SWAP). Because it is frequently useful to create a fresh copy of the stack entry just below the one on top (as FORTH's OVER operator does), this operation should be included as a hardware primitive. It is even useful to have the ability to access entries arbitrarily deep in the stack. Sometimes the depth within the stack of the desired entry can be specified literally by the programmer in the source code; at other times it is useful to allow the depth of stack access to be a computed variable. By covering the latter case, we cover the former as well. Thus, we will implement an operator called N-TH that will take the top stack entry as its argument, and replace it with a fresh copy of the *n*th item in the stack.

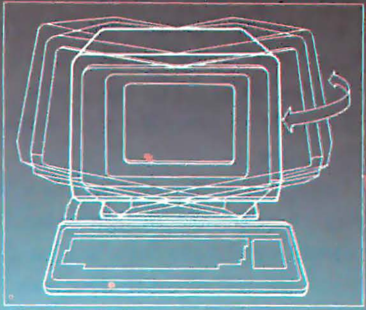
I have also found considerable use for a peculiar stack-manipulation operator, not ordinarily found in FORTH, called ROTATE. This operator bears the same relation to SWAP that N-TH does to OVER, that is, it takes the top stack entry as an argument and rotates out the *n*th item in the stack, placing it on top of the

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stack and deleting it from its previous position. This operator would be relatively costly to implement in hardware (presenting perhaps a level of difficulty comparable to that of implementing multiplication hardware). However, it is impossible to simulate the effect of this operator using a sequence of other operators. Also, in many situations, having it available can substantially simplify software development. For these reasons, ROTATE should be included as part of the instruction set presented here. One might also envision the need for an inverse-rotate operator, one that takes the top stack entry and inserts it a given depth into the stack. Such a capability is rarely needed, however, and using ROTATE, we could construct such an operation in software fairly easily.

Control of program flow is a vital aspect of software design. Handling of conditional branches is best done through the use of an IF operator that examines the top stack entry. If it is 0, IF loads the program counter with the address of the point to be branched to. This allows the programmer the freedom to make branches conditional on the basis of the evaluation of any arbitrary expression involving both arithmetic and logical quantities and relations. Note that, with a GOTO operator, an IF-THEN-ELSE construct can easily be provided via assembly-time macroinstructions without any need for further instruction-set support. At the point in the user's code at which the ELSE occurs, the assembler can automatically generate a GOTO pointing to the address of the end of the else-clause.

With a stack-oriented approach, we can achieve a fully symmetrical, easy-to-learn instruction set of enormous power without spending a fortune on silicon.

The other prime flow-controlling constructs of structured programming, such as DO...WHILE, REPEAT...UNTIL, and CASE, can all be implemented using various arrangements of IF and GOTO, generated, where desired, under the control of assembly-time macroinstructions.

One construct, however, stands out as being so useful that it deserves further consideration: the iterative loop. My proposed architecture contains a FOR instruction that expects upper- and lower-loop bounds to be presented to it on the stack; it also has a NEXT instruction that executes as a conditional branch back to the corresponding FOR, along with incrementation of the loop variable. This arrangement has a number of implications for our machine architecture. For one, it implies that we must have a second stack for storing this FOR...NEXT loop context (we knew we needed this extra stack anyway to

Text continued on page 142

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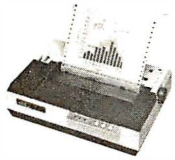
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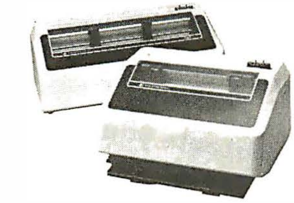
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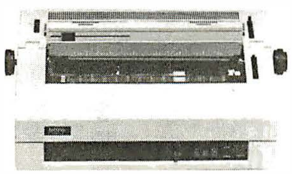
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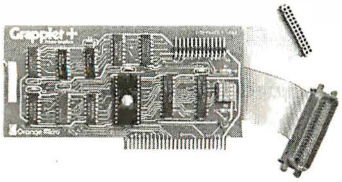
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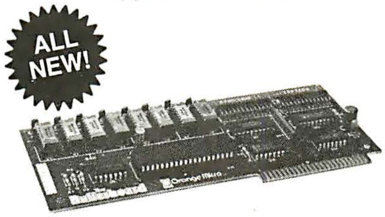


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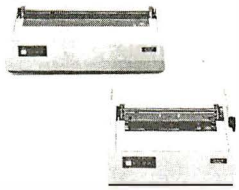
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support the subroutining feature). For another, it means that we will need two additional instructions, one to push the current value of the loop variable onto the main stack (the corresponding operator in FORTH is generally called either PI or I), and another to cause the current FOR...NEXT loop context to go away if the FOR...NEXT loop is terminated prematurely (sometimes called LEAVE in FORTH).

Whether or not there should also be a STEP instruction, for changing the loop step size, is open to debate. I have occasionally found the need for such an instruction, but have also found that convenient alternative software solutions are usually available where this need exists. For the sake of minimizing the cost of the silicon, I am in favor of leaving it out.

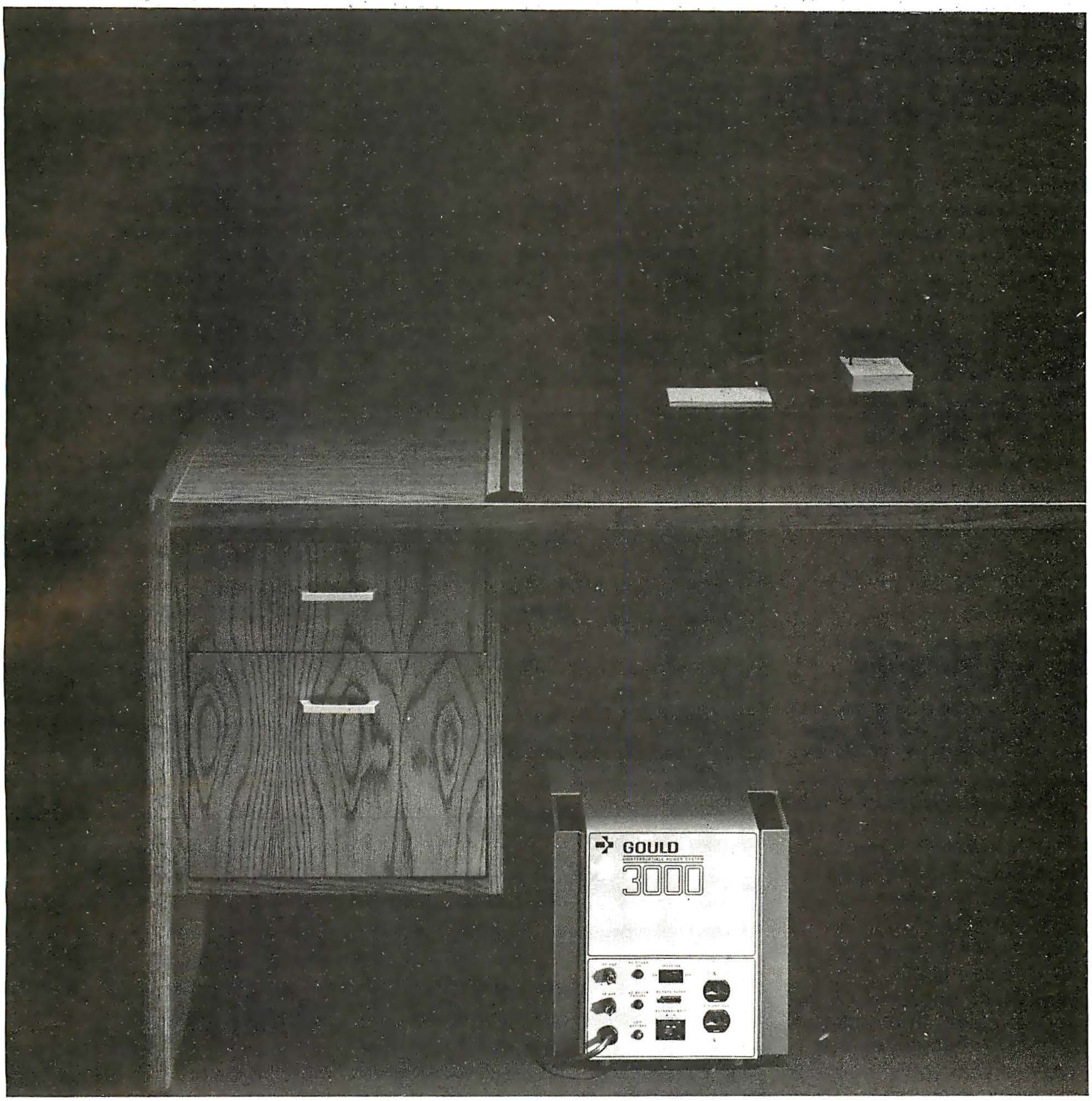
One area I have purposely left to the end of the discussion of desirable features is that concerning data types. So far we have spoken only about 16-bit integers. Certainly, however, hardware support for other data types could be extremely useful; single-byte data, for one, but floating-point numbers and character strings also come readily to mind. Here, however, we must be careful not to get carried away on the wings of overworked imagination. The support of floating-point arithmetic in hardware is a gigantic undertaking. If we are seriously interested in designing an *inexpensive* high-level machine, we will have to forgo this luxury for the time being. Perhaps in the year 1995, when chips are fabricated using genetic-engineering techniques and gates are only 5 or 10 protein molecules in size, inexpensive floating-point hardware will become feasible. Until then, software floating-point arithmetic or, at the most, coprocessor architectures should remain the rule for inexpensive systems.

On the other hand, single-byte data and character-string data present no such overwhelming design burden. We can expect that the addition of 8-bit memory-fetch and memory-store operations would require little in the way of additional processor logic. Also, if these operations are set up so that they behave just like their 16-bit equivalents except that they pertain only to the low-order 8 bits of each 16-bit stack word, all our existing 16-bit operators will work with 8-bit data as well. Character strings, being nothing more than sequences of single-byte data, should also be easy to support in hardware. If strings are represented on the stack in the form of length foremost followed by string body, with one 8-bit character per 16-bit stack entry, they are in fact very convenient to deal with, as experience has shown. I have found the string-push-immediate operation to be the most useful, followed by string-push-absolute (in which the string address is taken from the top-of-stack), and, somewhat less useful, string-store-absolute. This last operation, in fact, is rather infrequently needed, rather costly to do in hardware, and rather easy to do in software. Therefore, I think it would best be omitted.

The veteran FORTH user may be wondering at this point what all the fuss here is about. So far, everything we have discussed has appeared to resemble FORTH so strongly that to say we are not speaking of implementing FORTH in hardware would appear to be an exercise in semantics. This is no accident. As mentioned earlier, FORTH is currently the most popular stack-oriented high-level language, and any source-level compatibility that we can preserve between FORTH and the language that is proposed here can only be beneficial to users of both languages. The driving differences between FORTH and the language proposed here appear primarily at the object-code level. FORTH object code is threaded, whereas what we are discussing here is an object code based on executable op codes. This means that, for example, the way in which a subroutine invocation will occur here is for the address of the called routine to be pushed onto the stack, after which a CALL instruction will be executed in order to actually transfer control to the desired routine.

Nothing in what has been said so far has in any way touched on the question of I/O (input/output) struc-

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Operation Name	FORTH Mnemonic	Description
Push	<0-9>	Push a 16-bit quantity onto TOS
Pop	DROP	Pop entry on TOS
Dup	DUP	Push a new copy of TOS
Swap	SWAP	Swap TOS with NOS
Over	OVER	Push a new copy of NOS
N-th		Replace TOS with the TOSth deep stack entry
Rotate		Rotate TOSth stack entry out to TOS
Plus	+	Replace NOS with NOS plus TOS; pop TOS
Minus	−	Replace NOS with NOS minus TOS; pop TOS
Times	*	Replace NOS with NOS times TOS; pop TOS
Divide	/	Replace NOS with NOS divided by TOS; pop TOS
Modulo	MOD	Replace NOS with NOS mod TOS; pop TOS
And	AND	Replace NOS with NOS Boolean-AND TOS; pop TOS
Or	OR	Replace NOS with NOS Boolean-OR TOS; pop TOS
Xor	XOR	Replace NOS with NOS Boolean-XOR TOS; pop TOS
Not	NOT	Replace TOS with its 1's complement
Grtr	>	Replace NOS with logical NOS>TOS; pop TOS
Less	<	Replace NOS with logical NOS<TOS; pop TOS
Equals	=	Replace NOS with logical NOS=TOS; pop TOS
If		Jump to address on TOS if NOS=0; pop TOS and NOS
Goto		Jump unconditionally to address on TOS; pop TOS
Call		Call subroutine at address on TOS; pop TOS
Return	;	Return from subroutine
Fetch	@	Replace TOS with word pointed to by TOS
Store	!	Store NOS into word pointed to by TOS; pop both
Peek	C@	Replace TOS with byte pointed to by TOS
Poke	C!	Store single-byte NOS into addr on TOS; pop both
For	DO	Begin For...Next loop, from TOS to NOS; pop both
Next	LOOP	End For...Next
Pi	PI	Push For...Next counter value
Leave	LEAVE	Exit For...Next context prematurely
Spshim		Push-string immediate
Stgfch		Push-string absolute (string equivalent of @)

Table 1: *A list of operations that should be included in a microprocessor that could directly execute a FORTH-like high-level language. TOS means top-of-stack; NOS means next-on-stack.*

ture. This is because the most rational I/O structure known is the memory-mapped structure, and little needs to be said about it other than that it should be used here. Memory-mapped I/O is clean, infinitely expandable (to the capacity of the address space), and requires zero processor support. I have never understood why a computer architect would want to choose any other method.

We should also touch briefly on the question of interrupt structure here, if only to say that a simple one such as those found in the 6502 and the 6809 should perform admirably. Because of the stack orientation of our machine, nothing but the current program counter and program-status register (condition codes) need be saved on the stack when an interrupt occurs. Note the tremendous advantage that stack orientation gives us in this area over register-oriented microprocessors, with their need to save and restore all user registers that have the possibility of being altered by the interrupt-handling routine (indeed, the more powerful the processor, the more registers there are to be saved and restored—hence, paradoxically, the more time consumed in responding to interrupts). This alone should give our system the ability to respond extremely rapidly to interrupts of all kinds . . . not to mention the fact that our ability to write interrupt-handlers in high-level code will make the whole process considerably simpler and more glitch-resistant.

Putting It All Together

Table 1 lists all the basic operations that I have proposed for our hardware-implemented instruction



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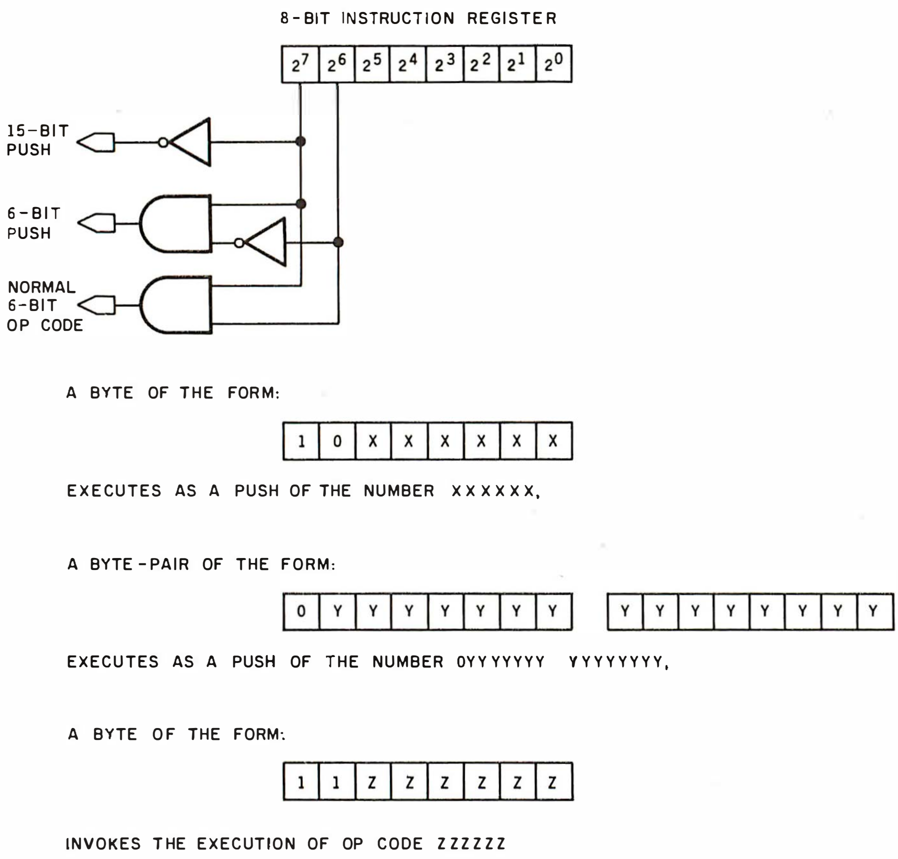


Figure 3: *An instruction decoding method for the proposed numeric push operations. Using only 1 byte, you could push any number from 0 to 63 onto the stack. With 2 bytes, you could push any number up to 32,767.*

set. Compared to existing microprocessors, it is remarkably short, simple, and straightforward. In particular, because so few op codes will be required to implement this set, we have the opportunity to do something quite astonishing here.

One of the questions I raised at the beginning of this discussion called attention to the possibility that some operations may be found to occur more frequently in typical user programs than others. This is in fact the case: experience has shown that the numeric push operation typically occurs far more frequently, in both time and space, than any other single operation. It stands to reason, then, that if we can somehow optimize the implementation of the numeric push for both speed and space efficiency, we can create an architecture whose performance is as unassailable as its ease of use. The fact that so few op codes are needed to implement the rest of the instruction set gives us this opportunity.

Let's suppose that we wish to stick with the standard of the 8-bit byte as the basic unit of memory addressability. The total number of op

A processor of this type could of course be programmed in many other languages, in addition to its high-level assembly language.

codes shown in table 1 is only 33. Allowing room for expansion and rounding up to the next higher power of 2, we decide to make allowance for 64 distinct op codes in our instruction set. This leaves 256 minus 64, or 192, bit patterns available for other purposes. What better use to put these to than as short, high-speed forms of the numeric push operation?

The design adopted for these short, high-speed numeric push operations is very simple. Small numbers such as 0, 1, and 2 are the most commonly pushed quantities. These could be set up in the form of ultrashort, single-nybble instructions, but this would gain us little because we are already presupposing at least an 8-bit-wide data bus for the purpose of reading in the ordinary op-code bytes. In addition, numeric pushes of larger numbers—typically those representing the addresses of data areas, jump points, and subroutines—are very common, and we would like to optimize these to whatever extent we can. For these reasons, I have found it desirable to recognize two distinct flavors of short-form push, one of which consumes 64 of the available bit patterns, and the other of which consumes the remaining 128. The first of these encodes single-byte pushes of numbers from 0 up to 63; the other acts as the first byte of a 2-byte instruction whose effect is to push numbers that, while large, do not cover the full 16-bit range.

The way this works is outlined in figure 3. When the processor enters the execution phase of its instruction cycle, it examines the high-order 2 bits of the byte it has just fetched from memory. If these 2 bits are both high, the remaining 6 bits in the byte are treated as a normal op code (e.g., ADD, FETCH, etc.). Otherwise, if the high-order bit of the byte is high, but the next-to-high-order bit is low, the remaining 6 bits in the byte are taken as a 6-bit quantity to be pushed onto the stack. Finally, if the high-order bit of the byte is low, the rest of the byte is taken as the high-order byte of a 2-byte quantity to be pushed, and the low-order byte of this quantity is taken from the next sequential location in memory. In this way, numbers up to 32,767 can be pushed onto the stack in 2 bytes or less—by locating one's object code within this address range, one can generate incredibly space-efficient code.

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There is a further bit of serendipity to be exploited here. Because, as now envisioned, all operations besides pushes of numbers exceeding 63 can be encoded in a single byte, we have reason to suppose that we may not need more than an 8-bit-wide external data bus in order to derive virtually the full level of performance of a 16-bit machine. All we need to do in order to take advantage of this is to separate out our two stacks from the user's address space and to place them (and their internal 16-bit-wide bus) entirely on-chip.

In fact, doing so will have the additional advantage that we can then implement the stack-manipulation and arithmetic hardware much more easily and directly—indeed, it even makes sense under these circumstances to consider making the processor cycle rate a significant multiple of the main-memory-access cycle rate. It is as though, without half trying, we have arrived at a low-cost architecture incorporating a high-speed cache memory (i.e., the stacks) whose contents are always guaranteed to be the most useful possible because its contents are entirely under program control!

Figure 4 shows a possible pinout for a microprocessor of the kind described here. Astute readers may recognize the pinout as being identical to that of the well-known 6502. Rearranging the pins slightly, one could imagine a processor of this kind being made pin-compatible with the 6809 or any of several other currently common microprocessors.

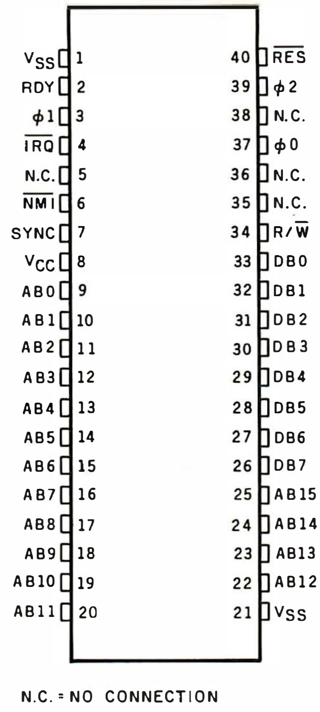


Figure 4: *A possible pin diagram for a proposed microprocessor that could directly run a FORTH-like high-level language. Some readers may notice that this is the same pinout as that for the 6502 microprocessor.*

Some Closing Remarks

A processor of this type could of course be programmed in many other languages, in addition to its high-level assembly language. Most if not all currently popular high-level languages, including BASIC, Pascal, PL/I, APL, FORTRAN, COBOL, LISP, and Ada, would be considerably easier to implement on a processor of this sort than they have been on existing microprocessors. More to the point, the compilers and interpreters for these languages would consume *much* less memory space on a machine like this than they do now, which would allow systems manufacturers to cut their prices substantially on systems supporting these languages.

The ideas outlined here were developed independently (with a great deal of help from Mr. Ken Wasserman) but are no doubt similar in many respects to those presently under discussion at all the major integrated-circuit manufacturers' engineering facilities. Stack-oriented high-level-language hardware represents an eminently practical, cost-effective mechanism for extracting minicomputer performance from microcomputer hardware—at "nanocomputer" cost.

The reason that this development has been so long in coming is due to a number of factors, not the least of which is that until recently software-oriented personnel have had little input into instruction-set design. In addition, an architecture of the sort presented here would probably not have been feasible prior to the advent of VLSI (very-large-scale integration) as a commercially viable mass-production technology.

In this connection, it is amusing to note that *Electronics* magazine once ran as part of a "New Year's Wish List" the fervent hope that Intel Corporation's Gordon Moore be granted "inspiration on what to do with a chip holding 1 million transistors." This wish may be granted yet. ■

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Maximizing Power in Multiuser Architectures

A system design combines the advantages of a single-processor multiuser system with those of both loosely and tightly coupled networks.

Mark Garetz
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The microcomputer industry is witnessing a trend toward more powerful (i.e., 16-bit) systems. At the same time we see a demand for systems capable of serving a number of users simultaneously. Multiuser environments can be achieved in many ways. In this article I'll discuss Compupro's approach to the problem, but first let's consider a few basic multiuser architectures.

The classic multiuser system consists of a single CPU (central processing unit), lots of memory, and the appropriate number of I/O (input/output) ports. The single processor serves all the users of the system by means of timesharing. The concept is fairly simple (although implementation is quite tricky): every few microseconds, a timer causes an interrupt to the system that causes the processor to suspend what it is doing for the current user and to do something else for the next user in line. In a two-user system, the processor switches back and forth between the users. In a system with more than two users, the processor usually goes around the circle, servicing each user in turn. A more sophisticated system might give certain users more time than others, according to each user's priority.

Although it is by no means simple to write, the software for the classic multiuser system is all written for one processor. This means that the operating system is in tight control of all the system resources (in theory, anyway). The effectiveness of this approach depends greatly on the efficiency of the hardware used to implement it. Hardware that performs well in a single-user environment may perform miserably in a multiuser environment (but we'll delve into that later). At some point, the maximum capacity of every single-processor multiuser microcomputer system is reached, usually at around three to four users. In simpler terms, we could say that the maximum capacity of the system is reached when the speed or performance suffers noticeably if another user is added to the system. With poorly designed hardware, this could happen at the two-user level; with well-designed hardware, it could occur as high as the eight-user level. Of course, the application of the system has a lot to do with the point at which performance seems affected. For example, in a computation-intensive environment, the maximum capacity of a well-designed system might be reached at four users. In a less intensive environment (such as a database inquiry system in which terminal use is low, and the chance of everybody's using the system at once is minimal) the maximum capacity of the system might be 16 users.

The point of this discussion is that every single-processor multiuser system will at some point reach its maximum capacity, and if the desired number of users exceeds the maximum capacity of the system, the system will slow down. The degree of slowdown depends on how many users the system is handling above its maximum capacity. Depending on the application, the slowdown may be tolerable. In most cases (with well-designed hardware) the system will still be many times faster than timesharing with a large computer at 300 bps (bits per second) over the phone lines.

But many of us are accustomed to fast single-user microcomputers and notice (and resent) the least slowdown. An obvious solution is to keep our single-user microcomputers and let the other people in the office get their own if they need computers. In many cases this is a good solution, although it's usually much more expensive than a multiuser system. The major problem with this solution is the difficulty of sharing common resources, such as an expensive hard-disk drive, a letter-quality printer, or a common database that everyone needs to access. With independent microcomputers, sharing of common resources is next to impossible.

Of course, it's possible to hook together all these independent systems to form a network of microcomputers. In a network, each connected device is called a node. Every node

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must have a certain amount of intelligence. A combination terminal/computer/mass-storage node (commonly referred to as a workstation), must have the raw computing intelligence to perform normal computing tasks and to send and receive messages over the network. If the node is a printer, it need possess only enough intelligence to send and receive messages.

Distributed Processing

Networking is one form of what is called *distributed processing.* The name comes from the fact that the processors are distributed throughout the computing environment. In the case of networking, these processors are located some distance from one another, and they are not linked together very tightly; that is, it would be very difficult for one processor in the network to control the actions of another. Appropriate software could make one processor *appear* to control another, but in reality each processor is quite isolated from the others. Such a system is said to be *loosely coupled.*

Another form of distributed processing involves multiple processors housed in the same cabinet. In this instance, a master processor usually controls the actions of all the slave processors. In a single-user environment, various parts of the computing task would be divided among the processors; each would perform a certain part of the task but simultaneously with the other processors, thus speeding up execution. This process is called *parallel processing* because many processors are used to complete the task, each processor running in parallel with the others.

Large-scale computers use parallel processing to get very high throughput. The technique is being implemented at the chip level as well. For example, the Intel 8086 uses two processors internally: one to handle operations on the bus and the other to decode and execute the instructions. This has a measurable effect on performance. The concept has been expanded further in the Intel iAPX 286 (also known as the 80286) with four internal processors, further subdividing the tasks. The effect on performance is dramatic.

The above-mentioned form of parallel processing is also a network of processors. However, it differs from the networks I discussed previously in being *tightly coupled*; that is, one master is in tight control of all its slaves.

In microprocessor systems, parallel processing has been used to increase the throughput of multiuser systems by essentially assigning a processor and independent memory to each user. The advantage of such a system is that the maximum system capacity is extremely high, usually only limited by the speed of mass storage. Such systems operate as networks, with each processor running independently. Some implementations are loosely coupled, and others are tightly coupled.

Hardware That Supports Multiuser Architectures

System designers can prevent per-

formance degradation in multiuser systems in several ways. The most obvious method is to use high-speed RAM (random-access read/write memory), high-performance disk-drive controllers, and powerful, high-speed processors. One of the reasons that Compupro has designed its family of products to such high standards of performance is to make certain that nothing will impede multiuser architectures. In fact, much of our hardware is designed to enhance the performance of multiuser architectures. Later in this article, I will describe a new processor board that brings unprecedented multiuser computing power to the realm of microcomputers and the IEEE (Institute of Electrical and Electronics Engineers) 696/S-100 bus. First, however, I will discuss other ways of enhancing the performance of multiuser systems.

Our processor and memory boards are the fastest available. Our disk-controller boards use DMA (direct memory access) transfers, which offer maximum throughput because they move data between an I/O channel and memory without going through the processor. Our I/O boards are designed to allow easy integration into a multiuser environment.

All of our products are designed for the IEEE 696/S-100 bus. The modularity and flexibility of that bus are vital to our ability to offer the wide range of multiuser solutions we are about to discuss. In our multiuser System 816/C, one central processor board's time is shared among all the users in the system. The processor board happens to be our innovative CPU 8085/88 dual-processor board, which allows simultaneous execution of both 8- and 16-bit programs. The operating system is a proprietary implementation of Digital Research's MP/M-86 that we call MP/M-816. It is a true 16-bit operating system; 8-bit applications are handed off as a task to the 8-bit processor for execution. This system can handle up to 15 users, depending on the application.

However, this system incorporates products that system integrators have been familiar with for years. Let's discuss some of our newer hardware designed specifically for multiuser applications.

Multiplexer Channels

IBM developed a type of data channel, known as the multiplexer channel, that is actually a separate, small computer dedicated to increasing the speed of input/output operations. The channel controls the flow of data between the system's RAM and the outside world. A channel that serves only a single I/O device (such as a terminal) is called a selector channel. A multiplexer channel serves more than one I/O device by interleaving data from the various devices under its control.

Compupro's MPX-1, a multiplexer channel for the S-100 bus, contains a 6-MHz 8085 processor, 4K or 16K bytes of RAM, up to 8K bytes of EPROM (erasable programmable read-only memory) using a 2764 device, an 8259A interrupt controller, and a complete TMA (temporary master access) interface to the bus.

The 8085, RAM, and EPROM allow execution of programs on the MPX-1 in parallel with the CPU on the bus. The interrupt controller monitors any or all of the eight vectored-interrupt lines on the bus. The TMA interface allows the MPX-1 to talk to any memory location or I/O port on the bus. Also included are a mechanism that enables the master CPU (sometimes called the host CPU) to get the MPX-1's attention and a mechanism by which the MPX-1 can cause an interrupt to the host.

The purpose of a multiplexer channel is to off-load the task of processing system interrupts from the host CPU. Consider what happens in a normal system when an I/O board causes an interrupt because a character is ready from a terminal. The CPU has been running a task for its current user when a second user presses a key. The I/O board receives the character from the terminal and causes one of the vectored-interrupt lines to go into the active state. The CPU must suspend what it is doing for the current user (which it does by saving its entire state on the stack) and jump to the service routine for that interrupt. The service routine reads the character from the I/O board and puts it into a buffer. First the service routine may check the character to see if it is any of several special control characters such as a back space or carriage return. If a line has been completely entered (indicated by a carriage return) it may set a flag so that the task that requires this input will know that it's ready for processing. Buffer pointers need to be updated along with a status byte that tells the number of bytes in the buffer. Then the service routine returns to a routine that restores the state of the previous task and resumes execution of that task.

This whole operation, simply to process one character, may take several hundred processor cycles for execution. This is time stolen from the original current task, which has the result of slowing that task down.

Now consider the same process if a multiplexer channel such as the MPX-1 is in the system: the same interrupt line is made active on the bus, but this time the MPX-1 sees the interrupt and the onboard 8085 responds instead of the host CPU, which continues its execution undisturbed. The MPX-1 then steals one bus cycle to read the character from the I/O board. The MPX-1 checks the character for special control characters and responds accordingly. Buffer pointers are updated, and the character may be written to a buffer in the host's memory space (stealing one more bus cycle) or be kept in a buffer on the MPX-1. A flag may be set if it was a carriage return (again stealing another cycle).

The difference is that the MPX-1 processed the interrupt in parallel with the host CPU, stealing only a few cycles from another task, rather than several hundred. It is clear that a multiplexer channel can greatly increase the throughput of a multiuser system. The MPX-1 is capable of performing many other tasks in a system (printer spooling is another), and more than one MPX-1 can be used in the same system.

Slaves and Masters

We have seen how the addition of a front-end processor can speed up the operation of a single-processor multiuser system, but in many situations even that speed improvement is not enough. In these cases, devoting a separate processor to each user is the only way to get maximum throughput, but it is also nice to retain the advantages of a tightly coupled environment.

Compupro has recently introduced two new products to satisfy these requirements. However, before I get into the specifics of these products, I should clarify the various ways that multiple processors can exist on the IEEE 696/S-100 bus.

Each S-100 system must have a master processor that is in control of the whole system. This is called the permanent master. In most systems, this is the processor board that we are all familiar with. The system may also have up to 16 temporary masters that request control of the bus from the permanent master. A priority system decides which of the 16 temporary masters gets control of the bus. The process of requesting and receiving control of the bus (and the subsequent running of bus cycles by the temporary master) is called TMA (temporary master access). TMA differs from DMA (direct memory access) in that a temporary master may either access memory or perform I/O.

The MPX-1 and all of Compupro's disk controllers are implemented as true IEEE 696 temporary masters. They request use of the bus from the permanent master and arbitrate for priority in the manner prescribed by the IEEE standard.

Memory and I/O boards on the bus are known as bus slaves because they are subservient to the masters. Any bus master (permanent or temporary) may talk to any bus slave. The bus-interface circuitry is much more complicated for a master than it is for a slave.

Compupro's two new products that address the need for a processor per user are called slave processors for two reasons. One is that there is always a powerful master CPU overseeing system operations (which we'll get to later). The other is that these processors are implemented as IEEE 696-bus slaves rather than as temporary masters.

We had many reasons for implementing our slave processors as bus slaves instead of temporary masters. As I mentioned earlier, the bus-interface circuitry for a slave is less complex (meaning it takes up less precious board space) than it is for a temporary master. When we get into the specifics of each slave processor, you'll see why that's important.

Also remember that a temporary master can access any memory or I/O location on the bus. If the slave processors were implemented as temporary masters, it's possible that one slave could severely mess up the operation of another slave, causing slave or system crashes. Protecting one user from crashing another or the whole system is vital. How protection was achieved by implementing the slave processors as slaves will become clear later.

Another important design consideration in developing a processor-per-user system was the limitation on

the number of temporary masters allowed by the IEEE 696 arbitration scheme. Up to 16 temporary masters are allowed, but that doesn't translate to 16 users. Remember that disk controllers and the like are also implemented as temporary masters, and this would cut down the number of users a system could support.

Last came the consideration of the software required for such a system. The orchestration of multiple temporary masters is a much greater task than programming a single, powerful CPU to handle interprocessor communication.

The first slave processor we designed was intended to fill two basic needs. The first requirement was to provide 8-bit *and* 16-bit capability for our 16-bit-only processor boards—CPU 8086/87, CPU 68K (the Motorola 68000), CPU 16032 (the National Semiconductor 16032), and CPU 286 (more on this later). When we developed the first 8- or 16-bit dual-processor board, the CPU 8085/88, we realized that we were fulfilling the very real need to use the newer 16-bit software while retaining the ability to use older 8-bit software. Unfortunately, we couldn't fit an 8-bit processor on every new 16-bit processor board, so we needed a slave 8-bit processor to give dual-processing capabilities to systems based on the newer processor boards.

The second need was for a high-performance, 8-bit node in a processor-per-user multiuser system.

Compupro has filled both these needs with a Z80B-based slave-processor board called the SPU-Z (SPU for slave-processing unit, Z for Z80). The SPU-Z contains the following: a 6-MHz Z80B processor, 192K bytes of DRAM (dynamic RAM), two RS-232C serial ports, an attention port so that the host CPU can get the SPU-Z's attention, a method by which the SPU-Z can cause an interrupt to the system, 2K bytes of start-up EPROM, and 4K bytes of fast, static, and dual-port RAM for communication between the bus and the SPU-Z.

SPU-Z Specifics

Let's examine the various portions of the board in more detail: The Z80B and 64K bytes of DRAM form the main execution engine for any 8-bit task. The two serial ports provide connection for a terminal and local printer for the user. Having the terminal and printer local rather than on the system bus helps to keep bus usage down and therefore increase the bus capacity.

The SPU-Z's dual-port RAM probably requires the most explanation. Dual-port RAM is memory that two processors can access. In this case, the two processors are the onboard Z80B and any other S-100 bus master (either permanent or temporary). The dual-port RAM is used by SPU-Z to transfer information to and from the host system. The dual-port RAM can reside on any 4K-byte boundary in the full 16-megabyte address space on the S-100 bus. Internally, the dual-port RAM can be made to overlay any 8K-byte section of the DRAM (along with the EPROM). Also, Compupro's disk controllers and the MPX-1 can transfer data directly to the dual-port RAM, again maximizing throughput.

Lastly, the SPU-Z may cause an interrupt to the host system, and the host system may signal the SPU-Z by its attention port, much like the operation of an MPX-1.

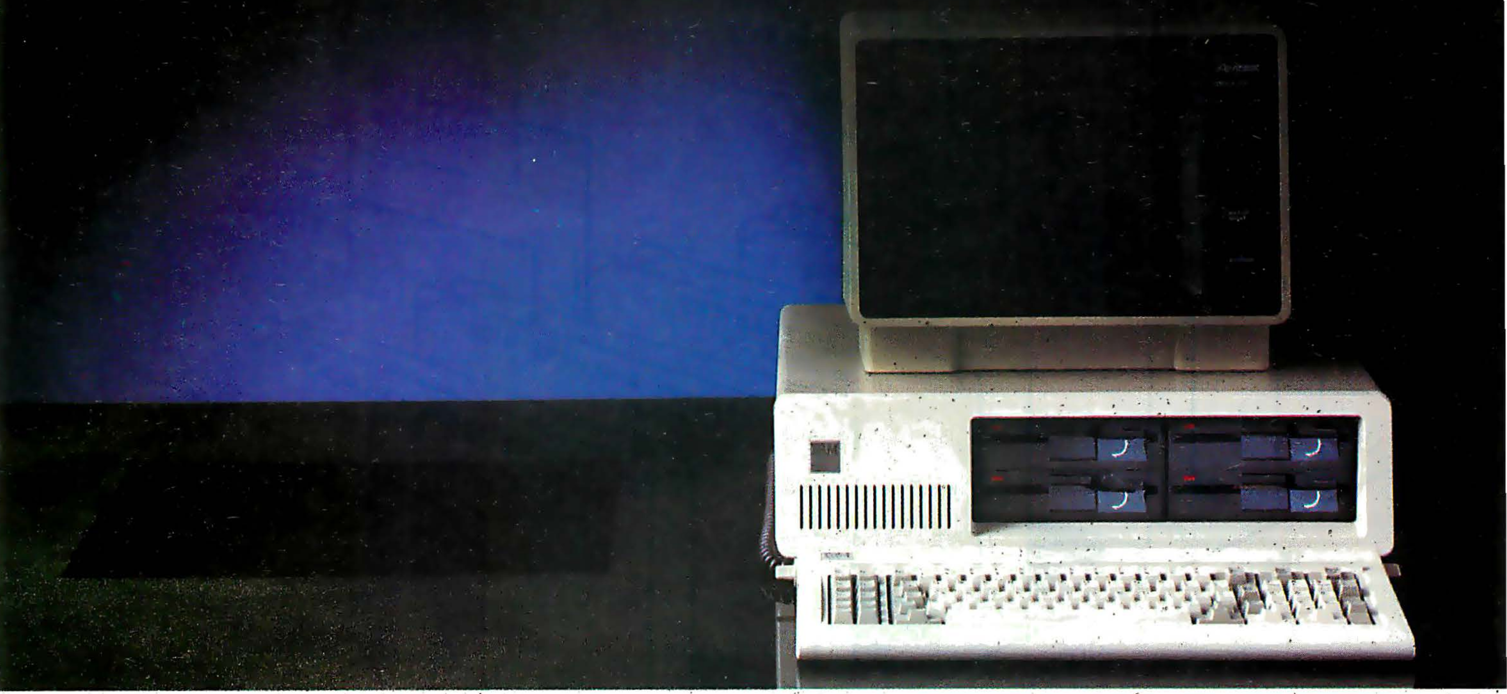
Super Slaves

We realized that the need existed for a truly high-performance slave processor, which meant that the slave itself should have 16-bit capability. High-speed number crunching was also at the top of the want list for users who needed a higher performance node.

Having one of the few multiuser systems in existence with a place for a high-speed Intel 8087 math processor (on the CPU 8086/87), Compupro was one of the first companies to realize a definite limitation of the 8087 in multiuser systems.

The problem is that the 8087 has quite a number of registers, all 80 bits long. Remember that to switch users, all these registers must be saved on

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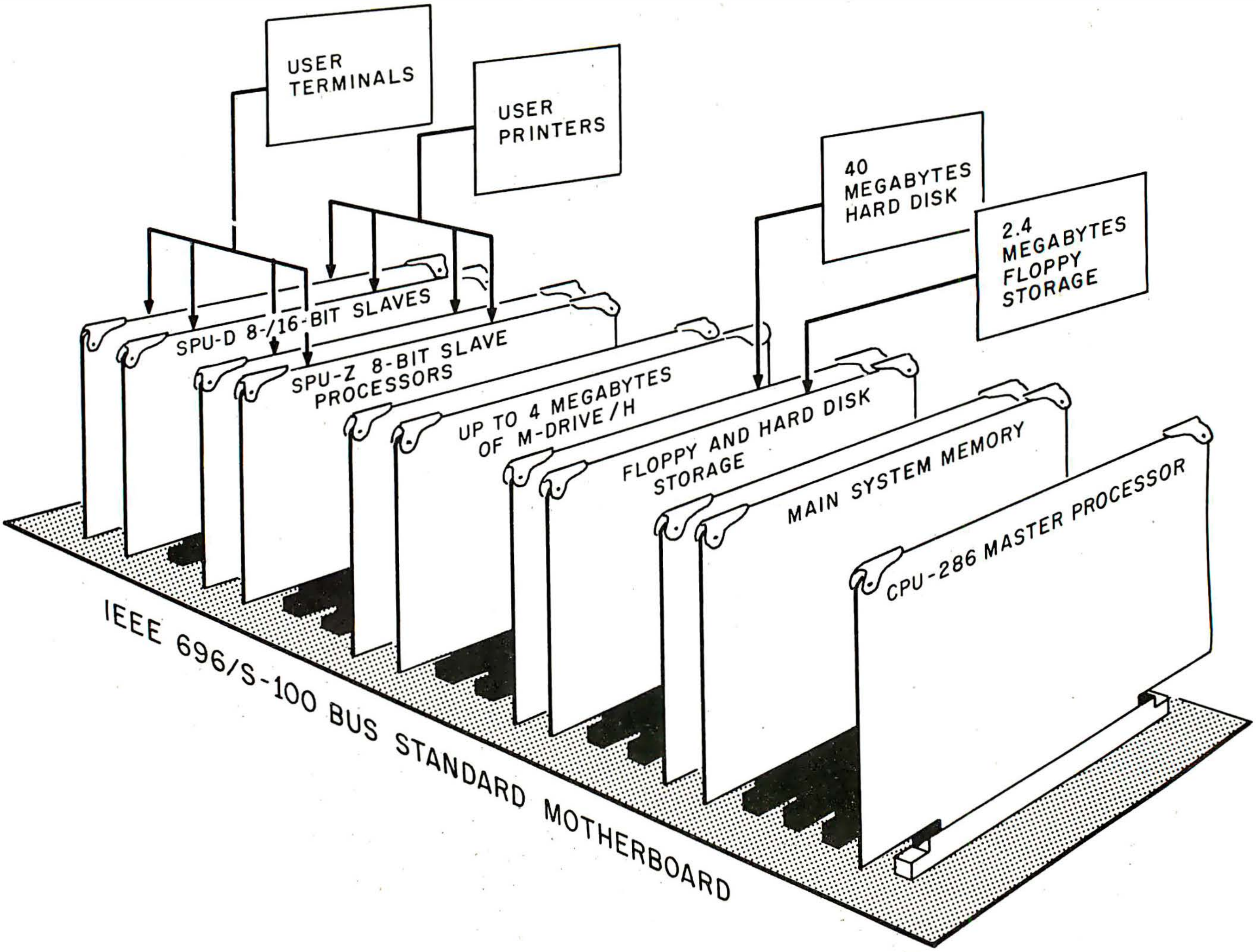


Figure 1: *A typical system configuration with a CPU 286 master processor (based on Intel's iAPX 286) with its main system memory and floppy- and hard-disk storage. Up to 4 megabytes of M-Drive/H solid-state disk is supported by the system for ultrafast access times. Any mix of up to sixteen 8-bit or 8-/16-bit slave processors may be plugged into the system. (Figure provided courtesy of Compupro Systems.)*

the pushdown stack (where a microprocessor temporarily puts data that will be needed later) and another user's previous register's contents must be moved into the 8087. Well, that's a lot of information to move that often, and that means operation gets slower. The solution seemed obvious to us: give users who need to crunch numbers their own 8087s.

Because many people are accustomed to using both 8-bit and 16-bit software, we decided to give this high-performance slave node an 8-bit processor as well.

So there you have the basic architecture for the SPU-D—an 8-MHz, 16-bit Intel 8088, an 8087 socket, and a 6-MHz Z80B. We also needed at least 192K bytes of DRAM (16-bit programs are big), the same dual-port RAM and EPROM as are on the SPU-Z, and two serial ports. That's a lot of computing power to give each user in a multiuser environment.

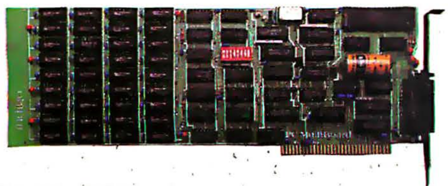
The SPU-D operates with its dual-port RAM in an identical fashion to the SPU-Z. The two boards differ mainly in the addition to the SPU-D of the 8088/87 pair.

Power and User Protection: CPU 286

Any of Compupro's previous CPU boards (CPU Z, CPU 8085/88, CPU 8086/87, CPU 68K, CPU 16032) can be used to control a system consisting of any number of slave processors (limited by the available slots in the motherboard), but we wanted to provide a processor board that could serve as the foundation of a multiuser microcomputer system with unprecedented power.

The CPU 286 is a processor board based on Intel's 80286 super 16-bit microprocessor, and is particularly suited to this task (see figure 1). The Intel 80286 can address 16 megabytes of RAM (from a 1-gigabyte virtual address space), has full memory mapping and protection built into the chip, and is designed to switch between tasks very quickly. In fact, the 80286 can switch tasks in only 17 to 22 microseconds (μs); by comparison, the admittedly powerful Motorola 68000 takes around 150 μs and its enhanced descendant, the 68010, takes 110 μs. Furthermore, the 80286 will run any code written for the 8086/88 but executes the code four times faster than an 8086 running at the same clock speed. Incidentally, the CPU 286 board runs at 10 MHz. It also has a socket for the 80287 math coprocessor chip, and additional circuitry to allow the use of either 8- or 16-bit memory.

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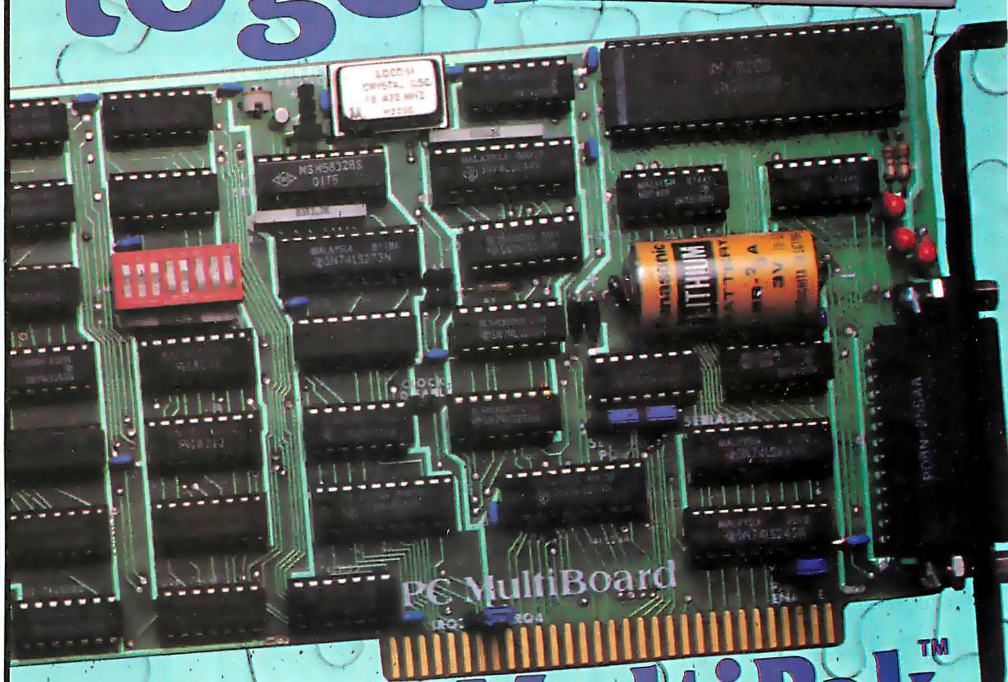
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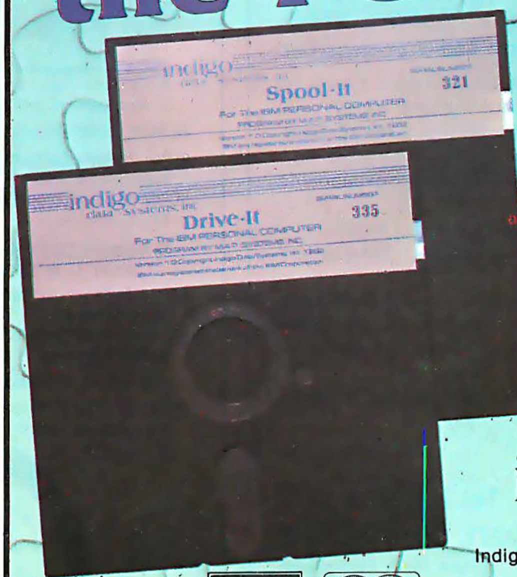
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Among the 80286's many impressive features, none is more important than its built-in memory protection. One of the drawbacks of a single-processor multiuser system is that it is extremely difficult to keep the sophisticated user from crashing another user or the whole system. Because a single processor is doing everything, it also has access to everything. It can get to the last bit of every user's memory area. Processors such as the 80286 provide a great deal of protection between users, but it's still possible for one user to crash the entire system.

The advantage of using the slave processors is that the master processor is in direct control of communications within the system. The master processor also never has to execute a program for a user; it's only executing the operating system. (In a single-processor system, the processor executes the program *and* the operating system.) It now becomes easy to restrict the system-wide effects of a single slave processor. Of course, sophisticated users can crash their own slave, but they can't affect any others. The system still runs.

Summing Up

We at Compupro believe that our multiuser architecture embodies the best of both network systems and single-processor systems. The architecture includes a network of high-performance slave processors that exhibits the best characteristics of both loosely and tightly coupled networks, with the network organized around a single processor of tremendous power.

Because our systems are based on the IEEE 696/S-100 bus, we can mix and match any combination of the multiuser systems I've discussed (software permitting). We could start out with a single-processor system such as a System 816/C, later upgrade that to use a CPU 286 as the master processor, and add an MPX-1 to increase throughput even more. Then we could add an M-Drive/H solid-state disk emulator (for up to 4 megabytes of super-fast storage). When that system reaches its limit (which shouldn't be for quite a while) we can start to give some users their own SPU-Zs. Those users who need even greater computing power can get their own SPU-Ds.

The Next Step: Networking Multiuser Systems

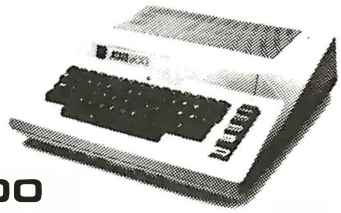
I haven't talked much about how Compupro proposes to connect several of the above systems into a network of multiuser systems. To be truthful, we're waiting for the dust to settle a bit with all the various networking schemes presently in operation before we decide which one to use. For the time being, several people are using the synchronous serial channels on our Interfacer 3 and 4 boards to connect multiple Compupro systems together. Imagine the potential of several 16-user, SPU-D/CPU-286-based systems all hooked together in a single network. We intend to continue producing the most powerful microcomputer systems possible while maintaining flexibility to use future technological innovations. ■

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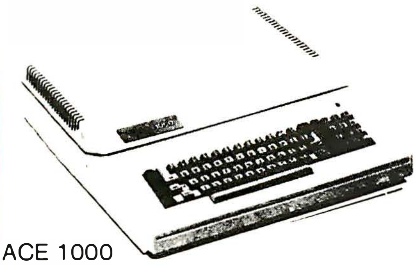
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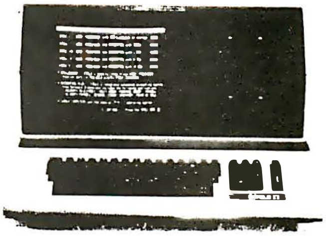
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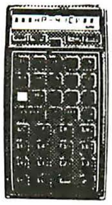
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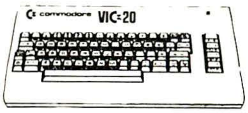
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Personal Computers in the Eighties

A recent study shows the market potential for the next decade is enormous.

Greggory S. Blundell
The Eastern Management Group
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Data-processing managers, manufacturers, and market analysts alike have raved in unison about the vast potential for personal computers. The diverse applications, the encouraging price/performance ratios, and the vast untapped market all promise big things for those small systems. But just how big will the future market be and what will it include?

According to a recent study by The Eastern Management Group, a firm specializing in market forecasts for the data-processing industry, the market potential over the next decade is enormous. The Eastern Management Group interviewed many of the major manufacturers and vendors of personal computers, some potential manufacturers of these computers, and more than 850 owners or operators of microcomputers. We weighed the information received from these interviews against several factors, including the present and projected economic climates, the key choices confronting the personal computer marketplace (such as that between 8- and 16-bit microprocessors), and the potential acceptance of microcomputers in the home, business, and educational markets throughout the decade. Combining all of these factors, we were able to make several forecasts by extrapolating two different types of sales data: that concerning personal computers sold as replacements and that concerning computers sold as new systems or additions. We then collected the results of all this work into a report called 'The Ten Year Market for Personal Computers." Here I will present several findings from that report that may be of interest to BYTE readers.

One of the principal forces contributing to the recent market growth has been the gradual acceptance of personal computers by corporate data-processing managers.

About the Author

Greggory S. Blundell is a market analyst with The Eastern Management Group, a New Jersey-based market-research firm. Mr. Blundell has participated in numerous studies on both the telecommunications and data-processing markets. He is currently involved in a study of the computer peripherals market.

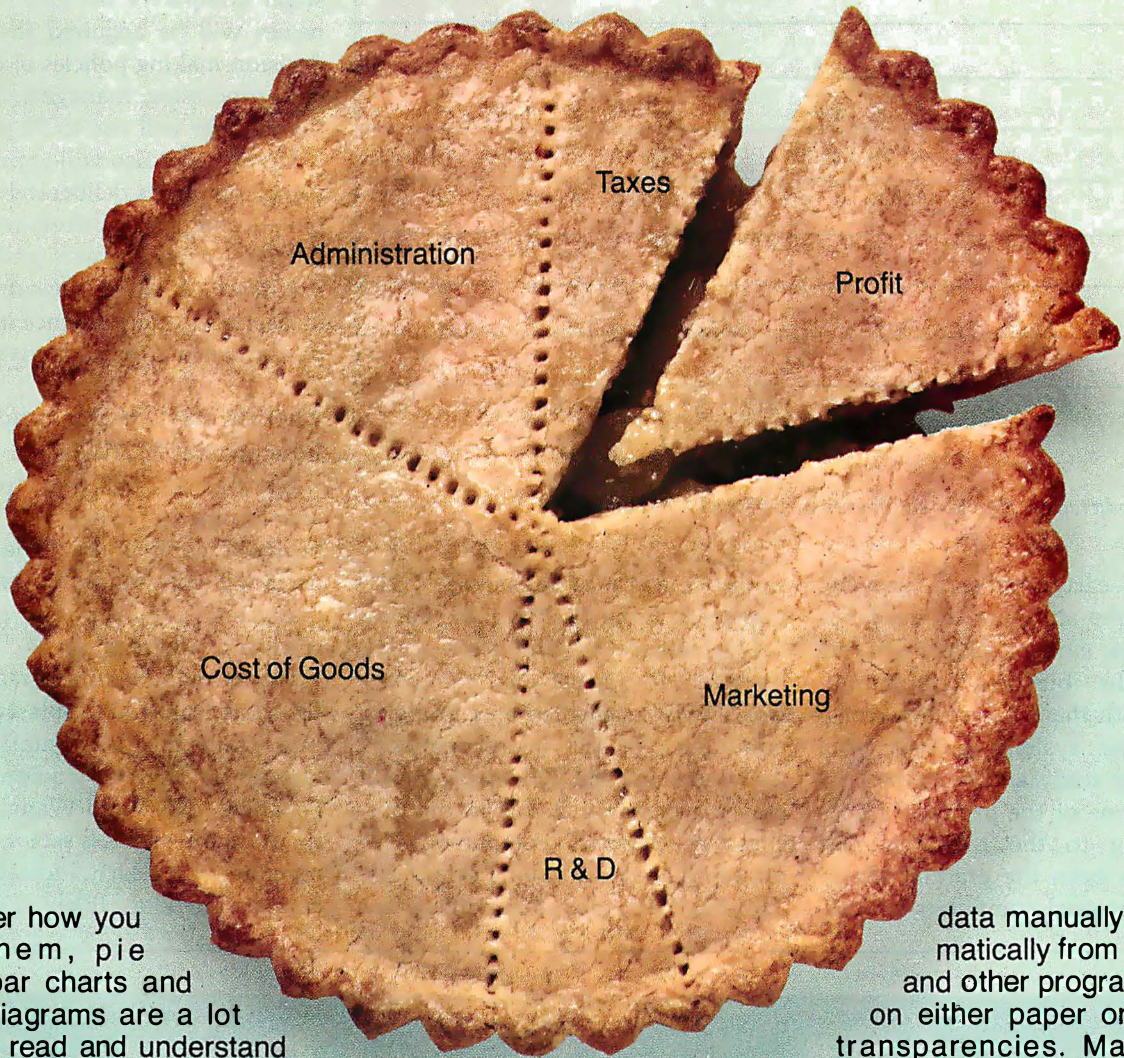
Growth of the Market

It turns out that 1982 was a banner year for microcomputers. Approximately 1,440,000 personal computers were shipped around the world; more than 1 million were sold in the United States alone. That translates into a 70 percent leap over the previous year's shipments—and that in the midst of an ailing economy. And this looks to be only the beginning (see figure 1).

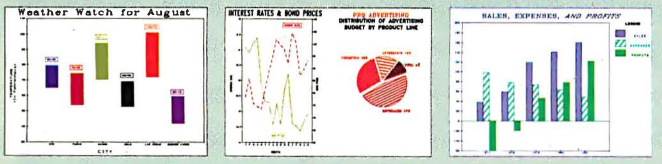
Why has this happened? For one thing, personal computers are undergoing a liberation from "basement toy" status. As this changeover accelerates, more and more home users, who at one time merely contemplated the purchase of a personal computer, will now actually take the plunge and buy one.

Furthermore, through the late

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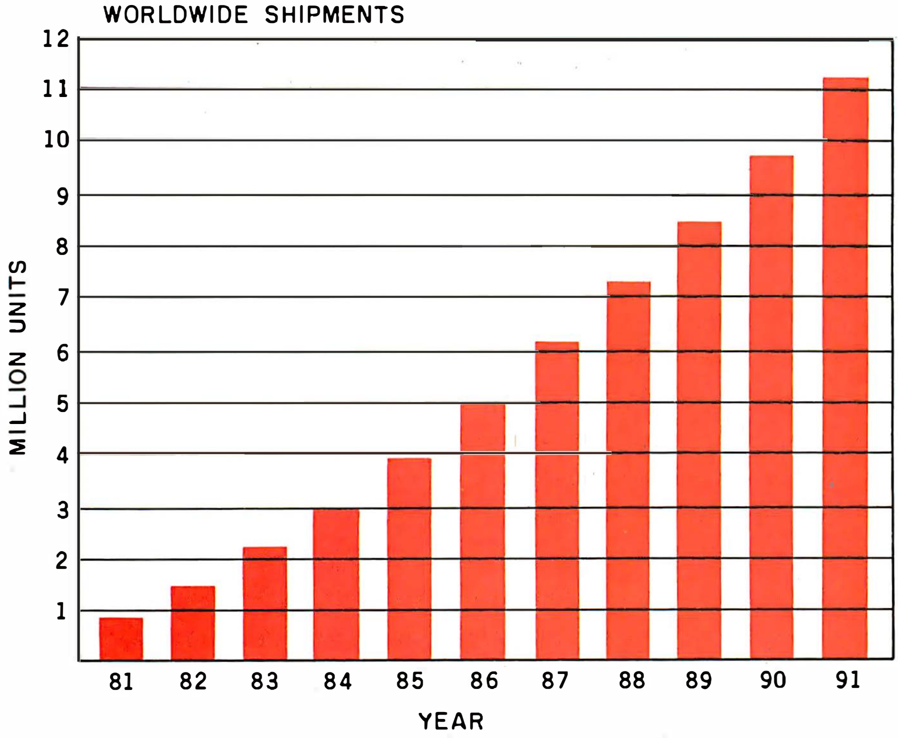


Figure 1: *Predicted worldwide shipments of personal computers.*

1970s and early 1980s, a growing change in the structure of the labor force became evident. New managers entering the business community brought with them a keen awareness of computer systems gained from both college study and home use.

Indeed, one of the principal forces contributing to the recent market growth has been the gradual acceptance of personal computers by corporate data-processing (DP) managers. From 1975 to 1982, an initial reluctance on the part of DP managers to use personal computers was slowly supplanted by a grudging admittance of the microcomputer's usefulness. In 1983, DP managers will play a commanding role in the purchase of personal computers. Not only will they be buying Apple IIs, TRS-80s, etc., for themselves, but they will also be laying down guidelines as to what systems may be used by their employees.

The change is significant. It indicates the emergence of a coordinated approach on the part of the business sector toward personal computers. In 1983, 45 percent of personal computers brought into businesses will be acquired through the decision-making policies of corporate data-processing managers; by 1985, the number will rise to 70 percent.

Home users also will approach personal computers deliberately and systematically. These buyers will include not only experimenters and pioneers but also educated consumers who measure system excellence in terms of performance and productivity.

The Business, Home, and Educational Markets

During the 1980s, most of the personal computer users will be in the business community. The primary users will continue to be white-collar managers, administrative personnel, scientists, and engineers.

Many manufacturers realize this. IBM has followed Apple and Tandy into the business market. The latecomers, Digital Equipment Corporation (DEC) and Wang, will also focus on the business sector. By 1985, revenues will clearly indicate that for companies like IBM, DEC, and



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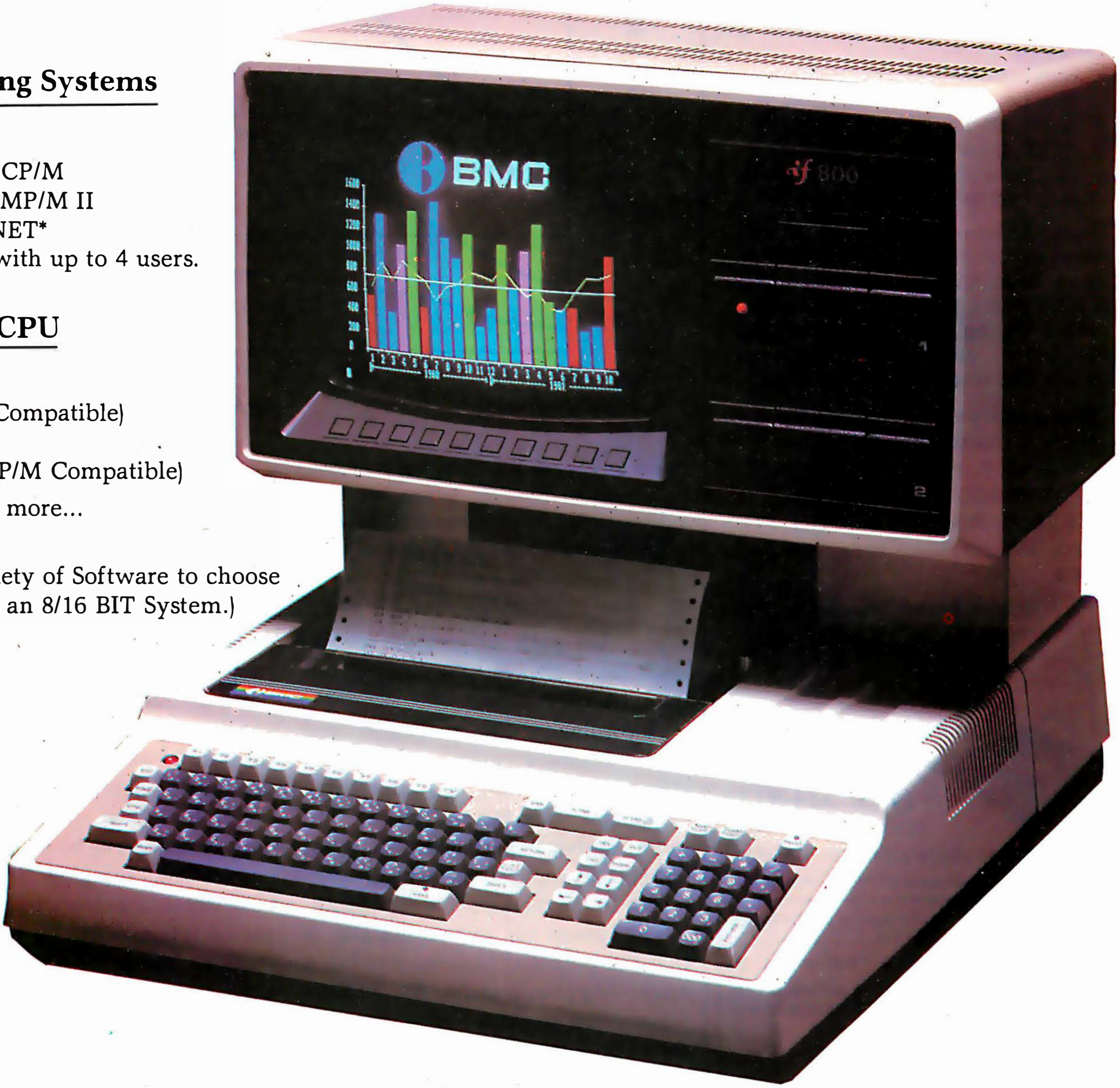
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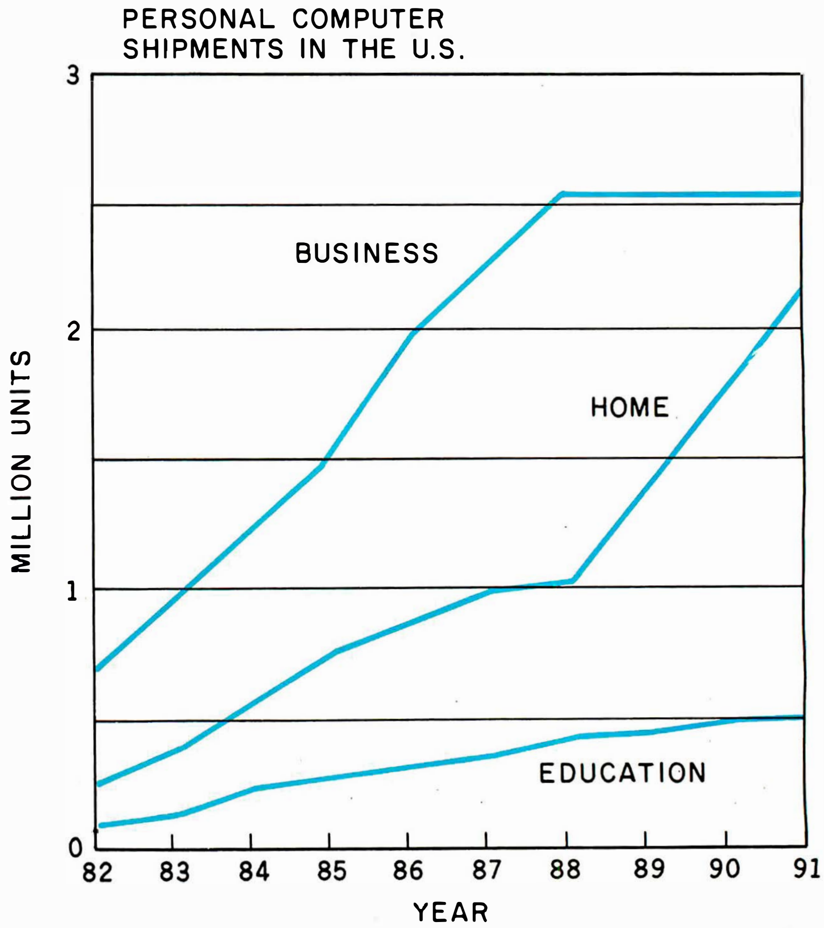


Figure 2: *The predicted shipments of personal computers in the U.S. broken down into three market segments: businesses, homes, and educational institutions. Although a majority of personal computers will continue to end up in businesses, an increasingly larger portion will be purchased by home users and schools.*

Wang, the path to greatest success leads (as it always has) directly into the business market.

Accordingly, DP managers and other business users can expect enhanced marketing and advertising campaigns directed at them, and more systems permitting a great variety of applications will be promoted in the marketplace with gusto.

The reason for this enthusiasm is that the potential business market is huge. Approximately 55 million white-collar workers are employed in the U.S. alone. At the end of 1982, 1,600,000 systems were spread among U.S. business establishments; thus only 1 out of every 34 white-collar workers could boast a personal computer.

Throughout the 1980s many corporations that have not yet purchased a system will buy one. By 1991, approximately 55 percent of all businesses owning one system will have invested in an additional personal computer. The result will be a substantial number of new personal computers claimed by the business sector each year. In 1983, 1,026,000 new systems will be shipped to U.S. companies, bringing the installed base (total units installed) of business personal computers up to 2,642,000. By 1988, about 12,500,000 will have been installed. As we embrace the 1990s, U.S. business establishments will have accrued an installed base of more than 15 million personal computers (see figures 2 and 3).

U.S. households will also begin buying personal computers at an increasing pace, although not as rapidly as domestic businesses. New low-priced systems such as the Timex/Sinclair 1000 (for a review in

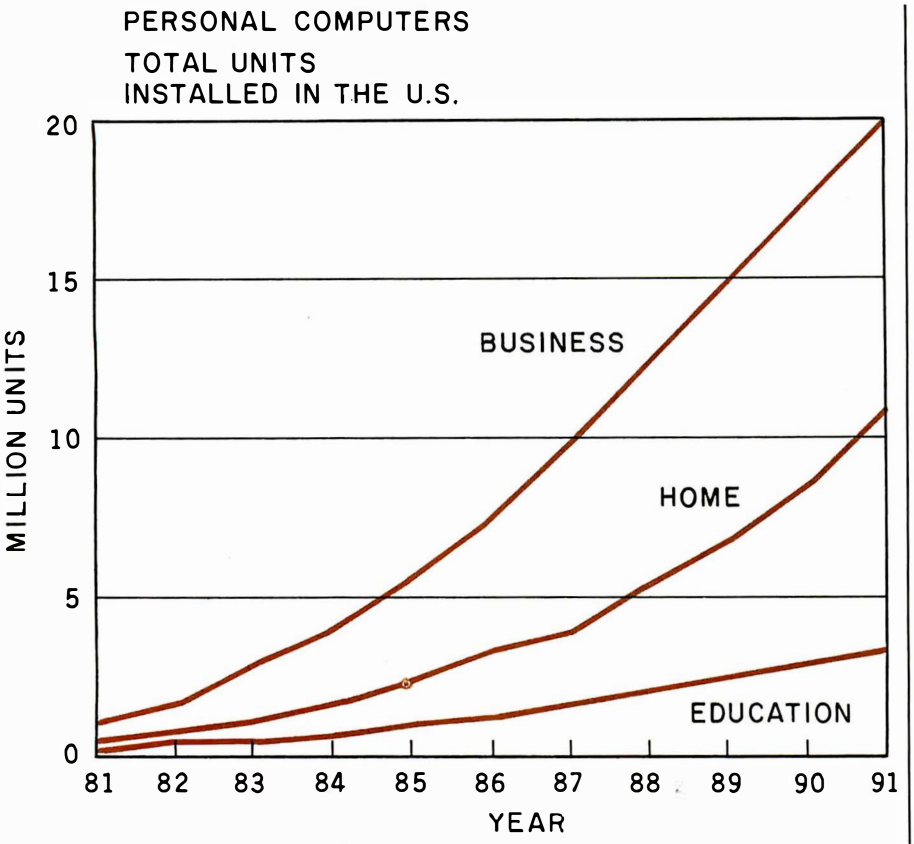


Figure 3: *The predicted total number of personal computer units installed in the U.S., broken down by market segment.*

this issue, see page 364), the Commodore VIC-20, and the Atari 400 will appeal to finance-minded households that once viewed personal computers as unjustified luxuries. Aggressive and clever advertising, such as that evidenced by Commodore, is aimed at the heart of the home market. Personal computer technology is becoming less a threatening concept and more a familiar acquaintance.

Families with annual incomes of more than $25,000 will account for the overwhelming majority (90 percent) of households investing in a system. Such a system will be purchased with money set aside for recreation. These households will naturally have fairly large recreation funds to tap and, therefore, be willing to approach the personal computer marketplace.

At present, 621,000 systems are scattered throughout U.S. households. One year from today, that number should jump to more than 1 million. According to our studies, five years from now, 4.2 million systems will be located in U.S. homes; and as 1990 rounds the bend, U.S. home users should account for 6.8 million systems (see figure 3).

A third part of the personal computer market triad, the education segment, will be slower to turn to personal computers than the other two. Lack of response to date has been primarily due to the poor economic factors plaguing school districts and universities. Simply stated, school budgets at the local level have not grown at the same rate as expenses.

Despite financial limitations, however, a change is in the offing. Computer training and literacy are on the rise at all levels of education. Using personal computers as teaching aids, universities and colleges are offering many courses in computer science, while at the same time providing easy access to the personal computer regardless of the student's field of study.

Basic data-processing courses are springing up in high schools and even

grammar schools. And, of course, there are those intriguing computer camps where children can attend one- to two-month courses in computer programming during their summer vacations.

Educational institutions are growing more receptive to computers each year. Their logic is simple: the investment of often less than $300 per student to introduce him or her into the intricacies of data processing is an investment well made. At this time, barely 250,000 systems exist in U.S. schools. By the beginning of 1990, that number will jump almost tenfold (see figure 3).

8 Bits versus 16 Bits

The proliferation of personal computers is not occurring in a vacuum. Several competitions are pulling and shaping the marketplace. One of these is the tacit yet intense battle between 8-bit and 16-bit personal computers.

Prior to 1981, very few 16-bit personal computers existed. Data-processing managers and home users studied the market and generally came away with an Apple II, a TRS-80 Model II, or a Commodore PET—all 8-bit systems.

But soon advances in semiconductor technology permitted a reduction in prices, and affordable 16-bit microprocessors began appearing in personal computers. During 1982, a wave of personal computers carrying 16-bit microprocessors washed over the marketplace. A majority of these systems were built around two microprocessors: Motorola's 68000 chip and Intel's 8086 chip. (Indeed, within the 16-bit microprocessor ranks, there seems to be a contest to see who will be king of the hill, Intel or Motorola. In terms of numbers, Intel holds an advantage. But, Motorola is coming on strong with its 68000, which was chosen by Tandy for its Model 16.)

The competition between 8-bit and 16-bit systems means a far wider selection, especially for the business segment.

As the number of systems carrying a 16-bit architecture increased, so too did the number of 16-bit operating systems. Currently, the two most popular 16-bit operating systems are Microsoft's MS-DOS and Digital Research's CP/M-86. But the competition here is also heating up, and more entrants, such as perhaps a 16-bit Unix-like system, are sure to enter the fray.

This competition between 8- and 16-bit machines means a far wider selection of products to choose from, especially for the business segment. The various 16-bit systems now available—and you can bank on more appearing as the year progresses—allow wider and more sophisticated applications. The upper echelon of the white-collar work force will turn to these 16-bit systems

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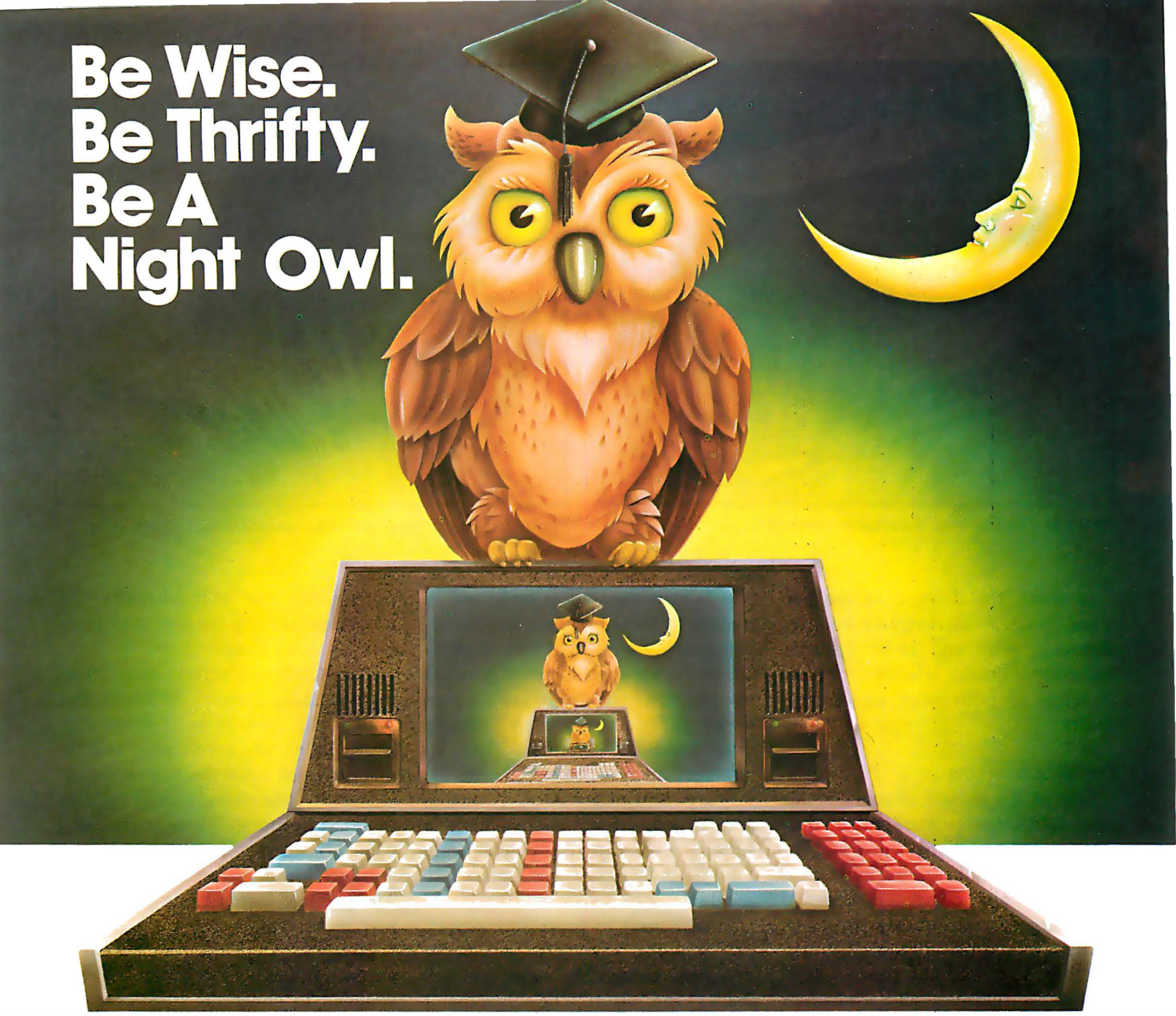
precisely because of their greater power.

So far, businesses have used personal computers most often for client records and accounting purposes, text editing, mailing lists, and financial planning. Applications such as stock/investment analysis and graphics do not appear to be as common. The power of the 16-bit systems will promote more sophisticated applications by businesses. Because of their price tag—a typical system costs $5000—these 16-bit personal computers will initially find their way into larger organizations. But that too will begin to change during the 1980s as 16-bit systems become less expensive. They will gradually supplant 8-bit systems within the business market segment.

The home market segment, on the other hand, doesn't really have a need for a personal computer carrying a 16-bit microprocessor. According to one of our surveys, the top four applications in the home market segment are, in descending order, games (entertainment), financial planning, education, and banking. The 8-bit machines on the market now can handle those applications as well as a 16-bit machine. And in the case of games, some 8-bit machines are distinctly better.

This does not mean 16-bit systems will not affect the home market. Quite the contrary, 16-bit personal computers such as the Fortune 32:16 and the TRS-80 Model 16 will have great impact. Because of the extremely competitive nature of 16-bit systems marketing, vendors of 8-bit systems will have to keep lowering their prices. And as prices are slashed, it is ultimately the home user who will benefit.

The shift from 8-bit to 16-bit machines will also affect the software industry. For a long while, independent software vendors focused on the 8-bit operating system called CP/M. But no longer are they concentrating solely on 8-bit software. Their efforts are more and more being directed toward the 16-bit world. For the business user this means a wider selection of enhanced software; and home users will find more software directed specifically toward them.



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Photo 1: *The Osborne 1 portable computer.*

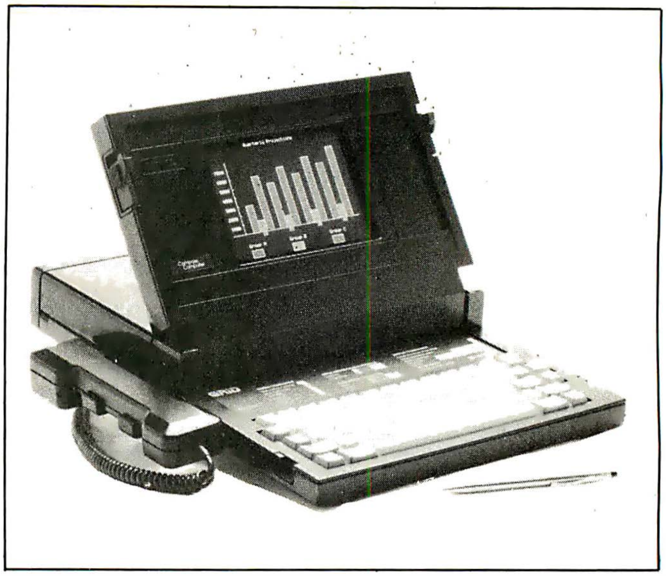


Photo 2: *The Compass portable computer by Grid Systems.*

In short, the division of the personal computer marketplace into two segments, 8-bit and 16-bit systems, will mean a greater selection for users in terms of both price and performance.

Portable Systems

One of the biggest changes in the personal computer marketplace during the 1980s will be a marked increase in the number of portable computers. Personal computers designed to be carried comfortably from one location to another are rapidly working their way into the repertoire of sales representatives and executives across the country. Businesses that already operate an Apple or Tandy desktop computer are investing in portable units such as the Osborne 1 (see photo 1) and using them as convenient and effective tools for the road.

Sales personnel, who make up more than 12 percent of the total white-collar work force, will probably be the prime impetus behind the boom in portables. Even those sales personnel who normally interact with terminals or executive workstations will be seeking company sanction of a portable system to be used for business trips, conferences, and, yes, overtime at home.

But sales personnel will not be the only ones using portable units. Managers, professionals, and even people from the clerical ranks will be turning to these briefcase computers. Consider for a moment that, depending on system sophistication, you can use portables for the following purposes: accounts receivable, mailing lists, financial planning, stock/investment analysis, sales tracking, inventory, limited graphics, invoicing, general ledger, and more—all in a system that can be conveniently transported from one place to another.

Indeed, next to processing power, probably the key factor is weight. Portable computers come in all shapes and sizes: The Osborne 1 weighs about 24 pounds; the Otrona Attache, 19 pounds; Grid Systems' Compass, 9.25 pounds (see photo 2); and the list goes on.

Other factors to consider are price, microprocessor size, and the amount of random-access read/write memory (RAM). These are good indicators of the operational scope of the portable system. Osborne, the company that virtually pioneered the portable computer market, is today the most popular. The computer's basic statistics are impressive even for a desktop unit: $1795, Z80A 8-bit processor, 64K bytes of RAM, two disk drives, and a small pile of software.

As the 1980s mature, the dominant trend will be toward greater power in smaller size. To date, the most sophisticated portable personal computer, and not coincidentally the most expensive, is the Compass from Grid Systems Corporation.

The Compass offers more than many desktop systems. At $8150, this system has 256K bytes of RAM *plus* 256K bytes of nonvolatile bubble memory and a flat display screen. It is, in effect, the elite choice of the portables. Corporate executives and other high-ranking white-collar workers make up the target market. The prestige factor alone should ensure its success.

Like the rest of the personal computers, different portables will be assigned to either the low- or high-end markets. Consumers will be able to select from a range starting with an inexpensive basic processing tool, priced at less than $100, and moving up to a sophisticated multipurpose computer system with a cost that could easily approach $10,000. Some key players to watch in this relatively new game are Osborne, Grid, Otrona, and IBM.

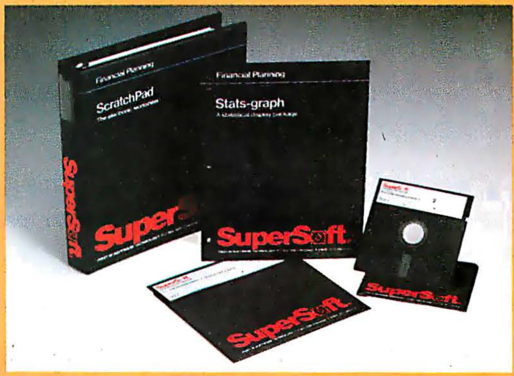
Each year, portable systems will account for a larger share of total personal computer shipments. By the end of 1983, 12 percent of all shipments will be portable; by 1990, the share will reach 25 percent (figure 4).

Personal Computer Pricing

Before we discuss prices, let's define exactly what we mean by *personal computer*. In putting our study

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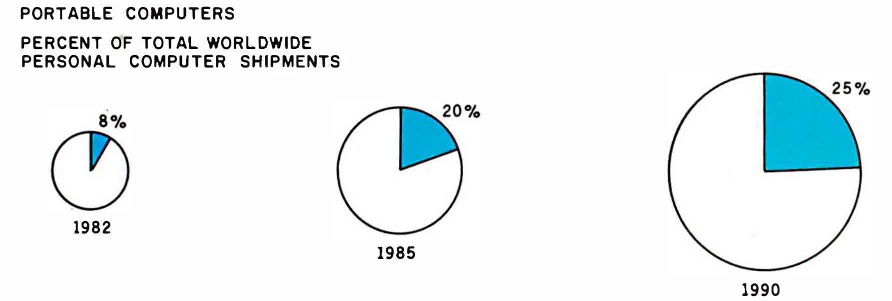


Figure 4: *Because of a growing response from white-collar workers, portable personal computers will account each year for a greater percentage of personal computer shipments.*

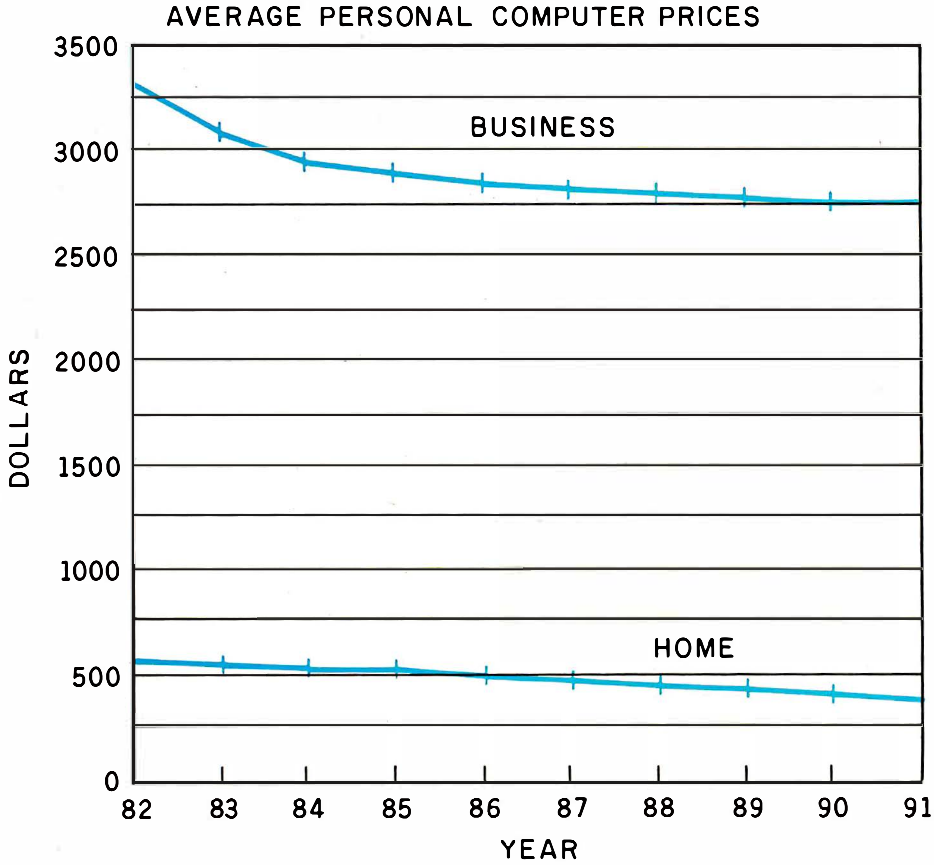


Figure 5: *Over a 10-year period, the average price of a business desktop computer should decrease from $3275 to $2700. Home computer prices should drop from an average of $530 to $350.*

together, we placed a price ceiling of $10,000 on personal computers. Home personal computers are simply defined as any personal computers that are to be used mostly in the home. Home system prices may or may not include peripherals such as disk drives and printers, depending on the computer.

What we considered to be the average price of a business system would cover the integral keyboard, monitor, and starting amount of RAM and only *necessary* peripherals, such as a low-cost dot-matrix printer and two floppy-disk drives.

The last seven years of this decade will see system pricing for home and business users either drop or remain stable while products deliver more processing power and more RAM. Between 1982 and 1987, average system prices will drop 20 percent, while the average amount of RAM will increase over fivefold (48K bytes to 256K bytes).

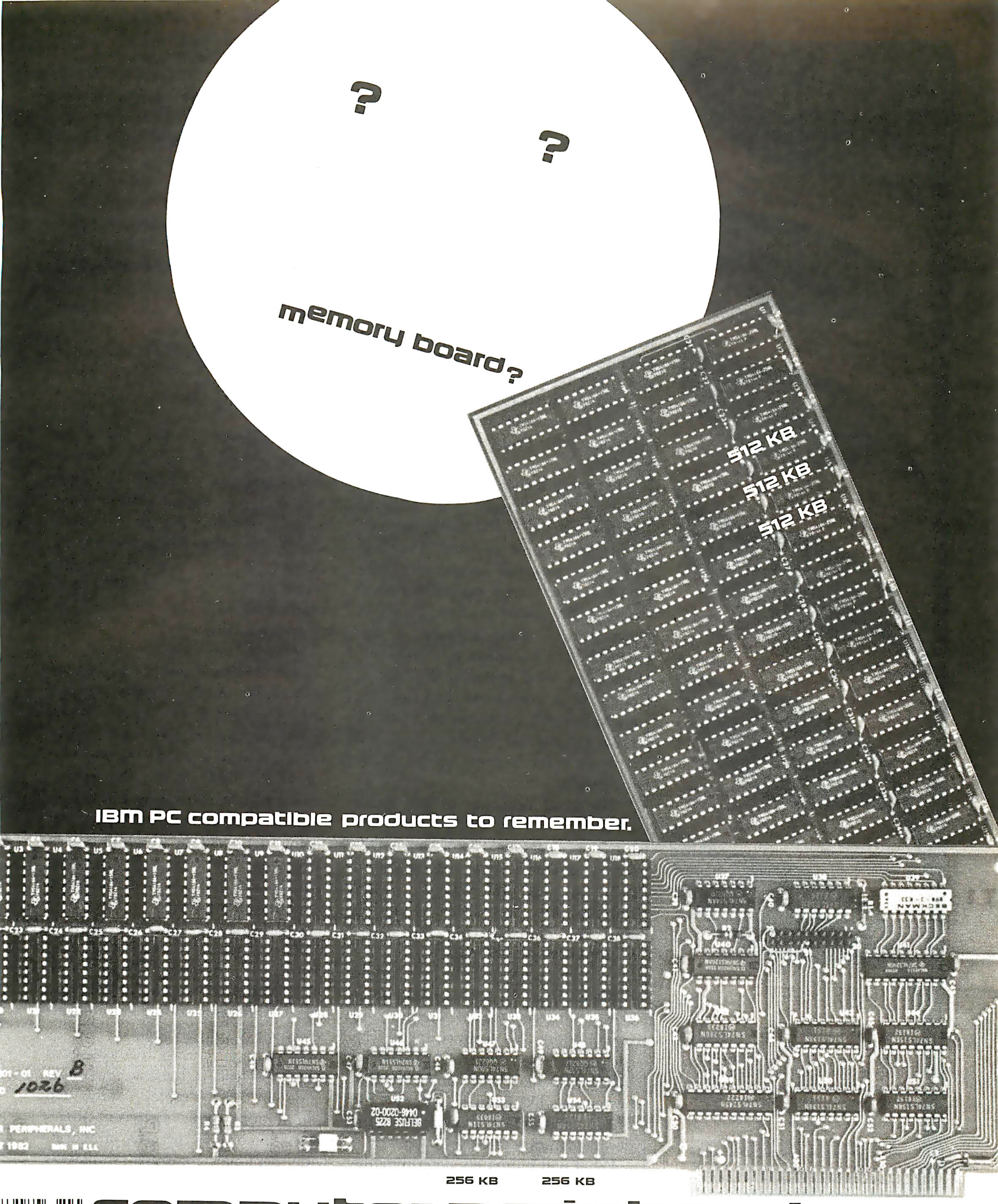
Beyond 1987 and into 1990, average prices will drop even more as home-user purchases of low-end models increase. In 1990, the average personal computer price, including basic peripherals and software, will be $2350, down from the early 1983 mark of about $2600.

Average pricing of the entire personal computer industry, however, is somewhat deceptive. The crux of the matter is that the range of systems available to the buyer will be significantly larger in the next 10 years than it was in 1980, 1981, and even 1982.

The average price of a home personal computer is currently about $530. These low-end systems are bought by both businesses and households, but their greatest potential by far rests with the home user.

With the exception of a few hobby kits, initial systems shipped in the home sector have for the most part fallen in the high-end range, i.e., generally $1000 or more. Until recently, the prices of home personal computers often paralleled the prices of business personal computers. There seemed, for instance, to be almost as many Apple IIs being set up in U.S. homes as there were in U.S. businesses.

Last year more companies like Commodore and even Timex became aware of the home market. The key to their marketing tactics, which many other companies will follow, is aggressive marketing through low prices. They know that home users recoil from the idea of paying what in many instances is the price equivalent of a fine used car for what remains in many eyes to be an elaborate toy. Therefore, much of the potential home-user market has remained untapped. Low-cost systems with enough RAM and application potential to be useful are what home users are now after.



?
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512 KB
512 KB
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The home market, accordingly, will see the average cost of a low-end system fall from $530 in 1982/1983 to $370 by 1990 (figure 5). Home users can look forward to more personal computers breaking the $200 and $100 barriers as manufacturers gear up production and begin slashing prices to compete in what is rapidly becoming an overcrowded market.

Although the typical cost of a personal computer sold in the business segment has recently been substantially higher than the price of a typical home system, the average business system too will enjoy a reduction in cost. Between 1983 and 1990, the cost of a typical business system will drop from $3300 to $2700.

Probably the single factor carrying the greatest weight for business system pricing is the battle between 8-bit and 16-bit systems. The new breed of personal computers, those built around 16-bit microprocessors, is generally priced at about $5000. A majority of 8-bit systems is approximately half that amount. Furthermore, 8-bit systems, in order to compete in both home and business markets, will continue to undergo price reductions. Prices of personal computers for business will naturally follow suit.

The final outcome of this price jockeying will be a truly complete range of personal computers. Different systems boasting different characteristics and carrying vastly different price tags will be available.

Companies on the Move

As 1983 begins to roll, three prime contenders for the personal computer crown emerge: Apple, Tandy, and Commodore. No surprise there. The question is, with established behemoths like IBM, and dynamic newcomers like Sinclair, will the "Big Three" still retain that title as the decade comes to a close?

What will ultimately determine the answer to that question is the market focus the various competitors adopt. Corporate market emphasis will vary depending on the structure of present strategies, and the unfolding developments within each of the three market segments. For example, it is indisputable that the biggest potential market is the home market. If the home segment were to live up to its potential, the company that could win the lion's share of that market (Timex/Sinclair?) would steal away the personal computer crown. But, home consumers are for the most part still extremely wary about the relatively new personal computer technology. Although they will gradually open their doors to personal computers, their purchases will not even come close to the number of systems absorbed by buyers from the business market, that is, at least not by 1990.

The business market holds the greatest immediate rewards for personal computer vendors. Business users will pay higher prices, make multiple system purchases, and, guided by the data-processing manager, boldly explore all the diverse avenues in the personal computer terrain. All the major vendors are aware of this.

Through the 1980s, then, the greatest emphasis will be placed on the business market. Apple, Tandy, and Commodore each have penetrated this market very nicely and established a good position.

But IBM, DEC, Wang, Burroughs, and other data-processing and office-product companies are already besieging that position. And they have a background in the U.S. business marketplace that will help facilitate the entire sales process.

Look at IBM. Big Blue shipped 40,000 systems in the first five months of market participation. DEC, Wang, and several of the other larger contenders should run into little difficulty following suit.

Accordingly, during the next seven years, the lead of the Big Three will erode. In 1983, Apple, Tandy, and Commodore will, between themselves, record 54 percent of worldwide personal computer shipments totaling 2.2 million units (19.3 percent, 17.7 percent, and 17.0 percent, respectively).

By 1990, the competition will have severely narrowed the gap. IBM will claim 11 percent of 1990 shipments,

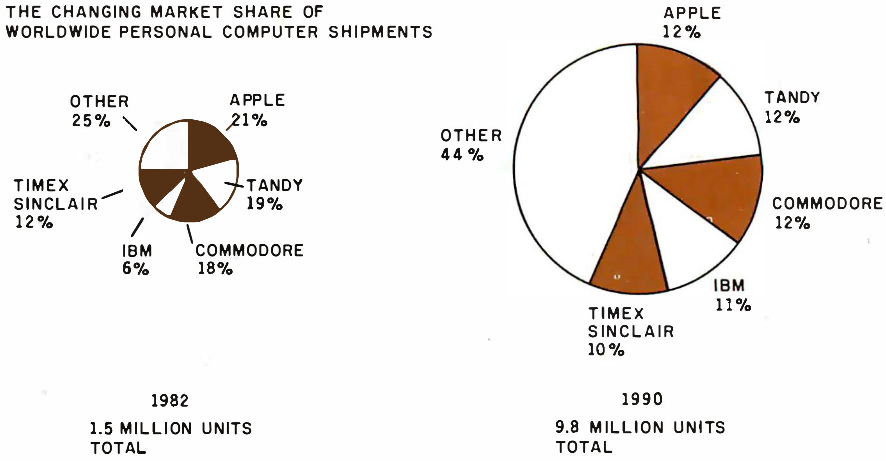


Figure 6: *As the 80s progress, the top five contenders for the personal computer crown will be Apple, Tandy, Commodore, IBM, and Sinclair. But, although the market will expand, the present Big Three—Apple, Tandy, and Commodore—will lose much of their present market share.*

exceeding 9.8 million systems. At the same time, Apple will ship 11.6 percent; Tandy, 11.5 percent; and Commodore, 11.9 percent (figure 6). Commodore, therefore, will eventually assume a slim market lead in shipments, thanks to a strong worldwide presence, and an almost equally divided tapping of both the home and business market reservoirs. But close behind and nipping away at the lead will be companies like IBM, DEC, NEC, and, of course, Timex/Sinclair.

Users can also look forward to new systems from unfamiliar sources. Last year showed conclusively that there still is enough time for more last-minute entrants into the personal computer race. In 1982, at least 10 new manufacturers announced plans to market a personal computer. But, although more will do likewise in 1983, the number will not be quite as high.

In the past three years, the influx rate of entrants into the personal computer marketplace has been nothing short of incredible. So far, the market has been open enough to support just about any and every interested vendor. But by 1990, too many personal computer vendors will be competing for a market that can no longer support them all. The inevitable outcome, by 1990 or perhaps as early as 1988, is an industry shakeout.

When looking back at the 1980s, future analysts will no doubt characterize it as a decade of transition for the personal computer industry. In this time frame, the personal computer industry will achieve maturity. System capability will undergo a constant upgrading, vendors will widen product lines, and buyers from each segment will increase their spending. In 1990, worldwide personal computer revenues will exceed $23 billion; domestic revenues, $14 billion.

Increases in memory storage, greater processing power in more compact sizes, and a general lowering of system prices will combine to effect an overall enhancement of the consumer's image of personal computers.

In the final analysis, what has happened in the early 1980s and will continue throughout the mid and late 1980s is the unfolding of a technological revolution. The advent of a more affordable, accessible, and versatile personal computer and its potential market acceptance have always promised to have enormous impact on U.S. businesses and homes. The coming-of-age of these small systems reflects not only a growing awareness on the part of industry of the needs of the mass market, but also a growing acceptance of personal computers in the minds of more and more consumers, who are now turning confidently to the personal computer marketplace, and who will continue to do so throughout the 1980s.■

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Circle 335 on inquiry card.



Up the creek without a paddle?

Or lost in space? Or down in the dungeons?

Whatever your games, you'll be happy to know that someone has finally come out with game paddles built to hold up under blistering fire. Without giving you blisters.

Apple Hand Controller II game paddles were designed with one recent discovery in mind:

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So we made the cases extra rugged. We used switches tested to 3,000,000 life cycles. We shaped them for holding hands and placed the firing button on the right rear side for maximum comfort.

So you'll never miss a shot.

A storehouse of knowledge.

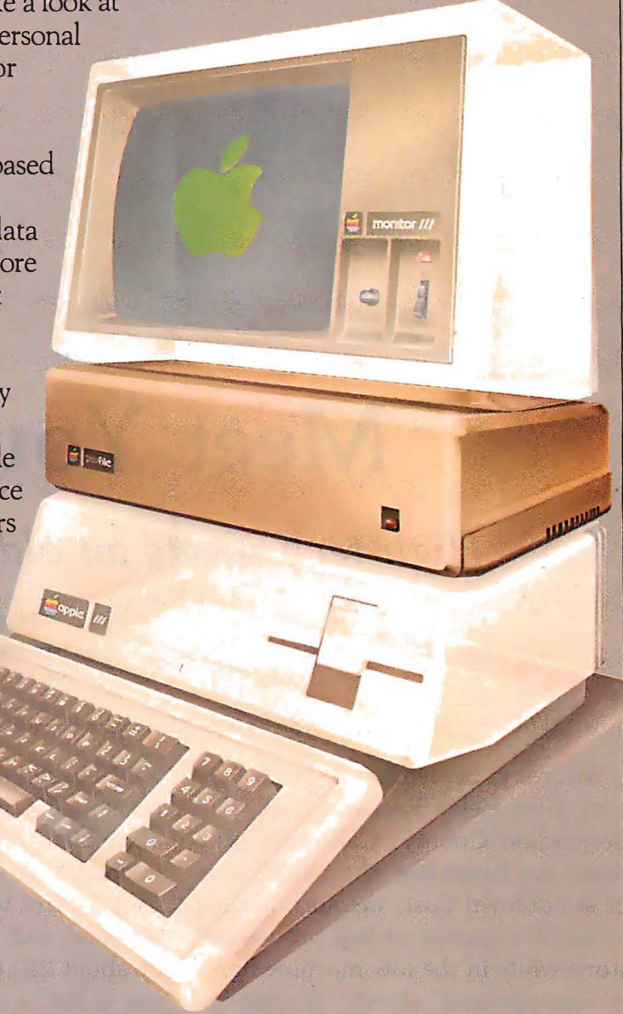
If you work with so much data or so many programs that you find yourself shuffling diskettes constantly, you should take a look at Apple's ProFile,™ the personal mass storage system for the Apple III Personal Computer.

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So now your Apple III can handle jobs once reserved for computers costing thousands more.

As for quality and reliability, you need only store one word of wisdom:

Apple.



Launching pad for numeric data.

Good tidings for crunchers of numerous numbers:

Apple now offers a numeric keypad that's electronically and aesthetically compatible with the Apple II Personal Computer. So you can enter numeric data faster than ever before.

The Apple Numeric Keypad II has a standard calculator-style layout. Appropriate, because unlike some other keypads, it can actually function as a calculator.

The four function keys to the left of the numeric pad should be of special interest to people who use VisiCalc.® Because they let you zip around your work sheet more easily than ever, adding and deleting entries.

With one hand tied behind your back.



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Meet You at the Fair

High-tech meets an old tradition at the US Festival.

Philip A. Schrodt
Department of Political Science
Northwestern University
Evanston, IL 60201

Saturday, September 4, 1982, 8:30 a.m. Glen Helen Regional Park, San Bernardino County, California. The desert sun hangs low, the air still clear of windblown dust, the surrounding mountains starkly etched brown and stone-white in the low morning light. A campground slowly stirring to life—100,000 people camped in a sandy treeless desert wash—100,000 people who had been amazingly considerate and quiet the night before, despite media fears of mass orgies and punk-rock terror. The US (United in Song) Festival, Steve Wozniak's $12.5-million gamble on human nature, is into its second day.

To the south, a perfect amphitheater the size of 40 football fields has been created. A stage the size of an office building towers above with 500,000 digitally coordinated watts of perhaps the finest sound system ever assembled. The festival has its own interstate off-ramp and its own airport control tower, deserves its own zip code, and, with a total attendance of about 250,000, is larger than any one of the 14 smallest members of the United Nations. It is Wozniak's folly or Wozniak's gift to the "US" generation, depending on your perspective. And it is the first rock concert ever to feature a computer technology exhibit.

The music doesn't start for at least two hours, but already a steady stream of people heads into the festival grounds. Joining the cattle drive through the entrance gate, passing the innumerable booths selling soft drinks, food, and rock memorabilia, I head down to the three large circus tents that house the computer exhibits. Wozniak (cofounder of Apple Computer Inc.) thought you could mix rock music and computers. Friday was the trial run. And it's working.

The exhibitors are feeling pleased. Yesterday was good, the traffic is coming through. In fact the exhibitors are feeling smug. They are the pioneers—they bet this thing would work and risked at least $1000 on renting and running a booth. They trusted Woz's latest crazy idea and feel it paid off, and they sound a note of contempt toward those in the trade who couldn't see how the rock crowd could benefit them. The exhibitors here feel vindicated—they *knew* this would work, they *knew* you could reach out to the masses. In short, they shared Woz's dream and participated, while the bulk of the industry stayed back.

I wander about, people-watching, talking with exhibitors, checking out the displays. There's something oddly familiar about this—the heat, the tents, the music, the technology. Yet this is supposed to be a novel experience . . . but wait, this déjà vu is nothing more than recollections of sultry August days in rural Johnson County, Indiana. Woz has reinvented the county fair!

Suppose an International Harvester, John Deere, or Funk Hybrid Seed dealer wanted to introduce his prod-

About the Author

Philip A. Schrodt is an associate professor of political science who specializes in international relations, mathematical modeling, and applications of microcomputers to social science. He is also vice-president of Polymath Associates Software in Skokie, Illinois, a firm that develops Pascal statistical software.

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uct to American farmers at the turn of the century. How would he do it? The county fair. He'd provide a good time, including a midway, horse races, beauty pageant, and country music. And he'd bring in his finest new tractor and combine and put them on display. The average farmer most likely couldn't afford the equipment, probably didn't even need it, but he'd look at it and admire it. So maybe he doesn't buy the combine, but he does buy the plow, and two years down the line when his neighbor is in the market for a tractor, he puts in a good word for the product he saw at the fair. And so gradually the fruits of the nineteenth-century industrial revolution reach out to the mass markets of the countryside and life changes beyond recognition.

Woz may have never been to a rural county fair, but he's got the idea down perfectly. With the county fair the fruits of the industrial revolution came to the rural masses; with the techno-rock concert the fruits of the information revolution can come to the urban and rural masses.

The industry, however, was split on the efficacy of this approach. Apple, Atari, and Mattel had large, professional exhibits. Commodore was well represented by its dealers, with VIC-20s much in evidence. The new portable computers, á la Osborne, could be found without difficulty in dealer displays. But the old-line electronics firms—Texas Instruments, Hewlett-Packard, Xerox, Tandy, and needless to say IBM—were no-shows.

Oh well, we'll have fun without them.

The Exhibitors

To see what Apple had accomplished, you just have to look around. Not only at the concert financed with Wozniak's millions, but also at the displays. At least 80 percent of the machines in use are Apple IIs, as impressive an advertisement as any. Apple's display is low key and confident—mostly hands-on demonstration graphics programs, no games—effectively drawing the distinction between a video game and a computer in a nonthreatening fashion. You can't walk by the display without being handed a half dozen Apple logo stickers. At night, Apple's hot-air balloon towers in the sky like a giant lantern, and the Goodyear blimp floats overhead with the message "Thanks Woz." If Apple ever has problems making it as a corporation, it might consider applying for tax-exempt status as a religion.

Atari has the largest computer exhibit, though it is concentrating on games and is pushing the Atari 400 rather than the 800. Atari provides an interesting twist by having the presidents of five of the largest Atari users' groups present, explaining software and talking about their groups. You see the human and social side of the computer revolution.

Mattel has the usual set of ultralow-resolution games. The display is just a larger version of what you'd find in a department store. Far and away the main attraction at Mattel is a new electronic drum set that consists of four pads about 3 inches in diameter, which simulates, rather im-

pressively, a complete drum set. It is always mobbed.

An assortment of dealers features business machines—usually either $10,000 hard-disk systems or $2500 portables that resembled you-know-what with a larger screen. Yes, the Osborne 1 has clearly emerged as the small computer people love to hate, replacing the TRS-80 in that vaunted position. And speaking of the TRS-80, Tandy is conspicuously absent from the Festival.

The real fun is at the small exhibits. The small exhibitors see themselves collectively as "the industry." They have had the time to talk among themselves and have analyzed their audience. This is not the West Coast Computer Faire. The consensus is that the Festival goers are about 1 percent people in the trade, maybe 9 percent who have some acquaintance with computers, and the remaining 90 percent no exposure at all, ever. So it is fun and a challenge presenting to people for the first time a technology that they've heard about, seen in the movie *Tron*, but never experienced firsthand. And the industry exhibitors are encouraging the viewers to sit down, relax, and chat a while, avoiding the pressure of the trade fairs.

The fascination of it is you can't tell the programmers from the druggies (always a problem, admittedly). I talk with a Silicon Valley dealer for the lovely new Jonos Ltd. "Courier" portable (Z80A, 64K bytes of memory, 9-inch video display, 3½-inch Sony floppy disks, state of the art): "What kind of people do we get? All kinds. This tall guy comes along, strange looking, missing a couple of teeth. Sits down and starts pounding away at the keyboard. I'm getting worried. Then he asks, 'Hey, how do you install Wordstar on this machine?' Gets into the operating system, pretty soon has everything switched around. And finally exclaims, 'What are you guys doing with *Apple II* Wordstar in this machine?' Turns out he's a programmer for Micropro. But he liked the machine and wants to help us upgrade the Micropro software for it. . . . Two other types of people are those who don't know the first thing about computing and those who stand here in front of the air conditioner."

Behind the Scenes

The Festival is organized by promoter Bill Graham's organization, and the computer people know a lot more about rock 'n' roll than Bill Graham knows about computers. When I unsuccessfully tried to get press credentials, they asked me how to spell BYTE, a somewhat discomforting inquiry. Never heard of it, and my explanation that BYTE was the *Rolling Stone* of microcomputing didn't seem to impress anybody. Meanwhile several exhibitors were giving detailed critiques of the US Festival, Woodstock, and the final Stones tour, all based on personal experience.

However, the organization was not flawless. Take the case of Rana Systems, the disk-drive company. Rana had a disk problem—10,000 disks to be precise. Frisbee disks.

Mike Mock and I talked standing in front of a 3-foot-high pile of Rana Frisbees. "We've been planning this promo for months. Talked to Unuson [a corporation formed by Steve Wozniak to fund this Festival and future Festivals] on the phone; they said Frisbees weren't on the prohibited list. Sounded great. We sent them the design so they could approve the US logo—no problem. So we show up here and *now* they tell us that Frisbees are prohibited at the Festival. . . ." So? "Well, we're having people fill out these little cards . . . ," Mike pauses to stop some people from helping themselves to Frisbees, "and we'll distribute the Frisbees through local dealers. Probably work out better that way anyhow, for the dealers. And Unuson's beginning to talk about helping us pay postage."

No Frisbees? At a rock concert? That's right—no wine, no coolers, no beach balls either, no Hare Krishnas, no Moonies, security everywhere. I suppose it's necessary—being smacked in the eye with a Frisbee is no fun—but Woodstock this ain't. Twenty years of organizing concerts and Graham's people have this to a science. *Los Angeles Times* rock critic Robert Hilburn called it "humane," which is accurate. It works—it is smooth, it is safe, but it is not spontaneous. Can't be. The trains run on time, period—Benito Mussolini would have been proud.

More Exhibitors

You can see an assortment of standard exhibits. Maxwell Corporation has the inevitable fake robot—body by Toys-R-Us and all the intelligence that could be programmed into 50 flashlight bulbs and a CB transceiver. Ah, for the day when we will be dealing with real robots. All of the music and art exhibits are getting a lot of attention. The outer space exhibits—L-5 Society, Delta Vee, and an elaborate UFO exhibit—are not: this is definitely a low-tech crowd. Curiously, the banks of video games also attract little attention. Music is the priority here.

And with a music crowd at this exhibition, the Syntauri Corporation, which produces a sophisticated synthesizer running on an Apple II, is in paradise. At the intersection of rock music and computers, with a framed letter of appreciation from some folks making a movie called *Tron,* and a booth right under the air-conditioning vents, Syntauri couldn't have it better.

Lenore Wolgelenter, sales director for Syntauri, explains the response they are getting. "The musicians are unfamiliar with this technology, but they are willing to learn. Show them that computers are something they can use, and they'll take the time to learn about them. It's only beginning. Only recently have we started getting calls from musicians who say, 'I want to do the following. . . . Can you tell me how to do it?' But that is the kind of thing we're hoping to encourage."

They're so right. I pass the Syntauri booth and a couple of guys looking very much at home with a keyboard are trying one of the demos. They are still there a half hour later, experimenting. Syntauri may have something: Rock music is in the absolute doldrums. Computers give composers an unparalleled creative tool. Maybe at the US Festival in 2001 the computers will be on stage, and the tents will display electric guitars and mechanical drum sets.

Outside of the music field, the response is harder to predict. For example, take the Stahler and Via Video exhibits. Stahler Company is a small San Jose firm that produces specialized drill bits for preparing printed-circuit boards without etching. It is largely a family operation, and Mary Stahler, daughter of the company president, was happy to have the opportunity to represent the firm at this fair for the same reason that her parents wanted to avoid it—the rock concert. Stahler is doing surprisingly well given the completely technical nature of the product—no Pac-Man here—and figured to about break even with the exposure as a bonus.

In contrast, one of the most impressive displays is Via Video's animation system. With the sweep of a pen across a graphics tablet, it can do the day's work of a Disney artist, in color and displayed on a 5-foot monitor. But this isn't attracting much attention. Perhaps an audience who has never tried to do computer animation doesn't appreciate the accomplishment. Magic is magic, after all.

Out to the Music

By midday, the exhibition tents are really getting crowded. Must be the heat. I'm getting tired of interviewing, and I've always wanted to hear Santana live. So, after an invigorating lunch of nachos and Tecate, I wander into the brave new world of the concert amphitheater.

Any collection of 200,000 people sitting in the desert sun is bound to be impressive. To take in the ambience of the place, one must appreciate two factors: skin and water.

Skin: the Southern California tan. These are not people who spend 12 hours a day in front of video displays, unless those monitors have real ultraviolet leakage problems. All shades of tan: tanned Nordic Caucasian blending into Sudanese African without missing a shade. Exposed skin—lots and lots of it. Unlike Woodstock, there is very little nudity here, as changes in fashion have made that rather unnecessary. With the advent of the string swimsuit, only a bit of imagination and a basic understanding of human anatomy separate fashionable dress from nudity.

Water: this site is desert—quite a beautiful bit of desert, dust-shrouded, sun-bleached mountains as fine as I've seen. But as in all deserts, the quest for water dominates. And so the "Ritual of the Spray Bottle," a new form of friendly social interaction, doubtlessly coded by the same segment of DNA that causes chimpanzees to pick lice. *Everybody* has spray bottles and is spraying everybody else with water. Massive fire hoses are mounted on the sound towers, soaking the audience, who loves it (as does this writer). Outdoor showers—pure genius—a half-acre of spraying water, fabulous, lowers the temperature a good 20 degrees, an ancient device, no self-respecting Persian or Islamic palace was without one.

It is, however, a rather subdued crowd for a rock concert. Very few

drugs—by rock concert standards that is, meaning I have been propositioned to buy dope only about 20 times and was there a good half hour before smelling marijuana. But the crowd isn't really lively, and the performers are clearly a bit uncomfortable with this. The heat, the economy, the security, or maybe just the 1980s?

Had any of the music fans been to the tech exhibits? Just look for the promotional material. Apple decals everywhere. But then, you couldn't drive down the main streets of Cairo, Egypt, last summer without seeing Apple logos everywhere, so that isn't surprising. But Syntauri stickers are seemingly on every third person. Link Systems is making a big hit with its (prohibited) Datafax visors, which read "Tame the Data Monster." Here are thousands of people who don't know what a database manager is, much less know Link from Stoneware, but they've got those visors on.

Computer nerds? Yes, I saw one—University of Arizona Department of Computer Science T-shirt, wire-rim glasses, white cords, pale complexion, looking like he was dreaming of a 32-bit microprocessor rather than taking in the music. Classic nerd. But I saw only one.

Santana is fine, with a guest appearance by Herbie Hancock, but time to get back to work. If you want a review of the music, check *Rolling Stone*. Besides, by now I'm a bit leery of the dust and heat. I had stayed out most of the day Friday, and around 6:00 p.m. Friday evening, I returned to my tent with every expectation of suffering an agonizing demise via a combination of heatstroke and asthma.

By midafternoon Saturday, most people have had their fill of the heat, and there is a general movement toward the tents as the temperature rises to the daytime maximum. The exhibition tents are air-conditioned, remember? So in the afternoon, they really start getting the traffic. How, the scoffers had asked, are you going to get a bunch of rock-crazed hippies wandering through these industry tents? Air-conditioning and 105 degrees does it nicely. And the exhibitors just smile. . . .

Still, not everybody was pleased with the turnout. Take the case of the new magazine for the IBM Personal Computer, *PC*. Its booth was abandoned Saturday morning. As I heard the story from the folks at *Softalk*, who were doing a brisk business in giveaway posters, *PC*'s publisher had given up late Friday. The publisher's assessment: "Look at this crowd. Do you see anybody who can even *afford* an IBM PC?"

Brilliant deduction, Sherlock! See that scuzzy looking guy standing there—filthy old jeans, a stupid felt hat that's been through too many rainstorms, idiotic T-shirt with a big fat raccoon on it? Well, friend, he's made the purchasing decisions on $20,000 worth of microcomputer equipment the past two years, influenced the purchase of another $20,000, and he's got $5000 in a grant and is trying to decide between an Apple III and IBM PC. I know—he's me. Appearances don't mean much. That woman you were ogling in the bathing suit that contains slightly more material than an 8-inch floppy is president of a software consulting firm and those wizened old dudes with the gold dog tags that say "Woz Guest" in Epson expanded print aren't exactly tyros in this business. But if you'll talk only to those done up in three-piece suits, you won't find much business here.

But protective camouflage aside, it makes good business sense to talk to that 90 percent who don't know a thing about computers. There you have Jane Six-Pack, out with her boyfriend listening to Tom Petty and the Heartbreakers. She can actually play with the graphics tablet on an Apple II and draw pictures with it and see computers in applications more sophisticated than a Space Invaders machine. She can't afford an Apple, but that VIC-20 or Timex/Sinclair 1000 is certainly inexpensive enough, and her child is going to be in school in a couple of years and the school board really should get a couple Apple IIs or Atari 800s. And hey, look at that, you touch this dot and the figure turns upside down; this is kind of cute. We are *never* going to


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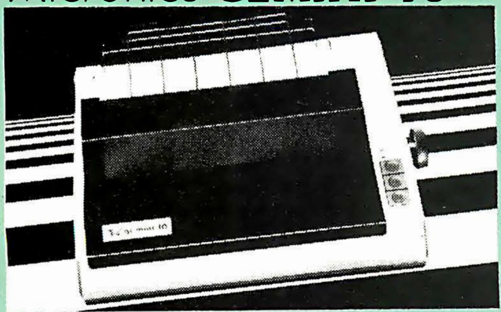
get that audience into Computerland, and they are 80 percent of the consumer market.

Have you ever considered just how intimidating the average computer store is? "Why yes sir, you would like to touch our new Wombat 128K Supermicro? Most certainly, sir. Just show us your American Express Gold Card, permit us access to your Swiss bank account so that we may check your net worth, and I'm afraid we must surgically remove your left arm for collateral, and then you are welcome to read the manual." I've been programming for 15 years, and I get intimidated by most computer stores. Furthermore, about 90 percent of computer sales personnel fall into two categories—ignorant and arrogant—with about two months experience separating the two.

To have a truly *personal* computer market—as opposed to an elite computer market, or a Space Invaders market—the industry is going to have to reach the masses. Not just the computer nerds, not just the Merrill-Lynch crowd, not just the college students. The mass market. And there is no better or more natural way than the rock concert and its analogs. It worked for John Deere and International Harvester, it will work for Apple and Atari—and Syntauri and Link and Rana and Microflow and Stahler and dozens of other small firms that took the chance to exhibit here.

Monday morning. Driving back north, California highway 101, soon to penetrate the heart of Silicon Valley but now in the rich agricultural Salinas Valley, John Steinbeck's country. Dodging trucks hauling cauliflower, tuned in to KNBR, a San Francisco soft-rock station, low-class stuff, for jerks like me who don't care enough about music to install an FM radio and will listen to anything that isn't disco. "The next hour of music is brought to you by Osborne, the personal business computer!" The Osborne 1, that aggravating microscreen turnkey system, advertising on a *rock 'n' roll* station! And doubtlessly laughing all the way to the bank. The personal computer revolution is only beginning. ■

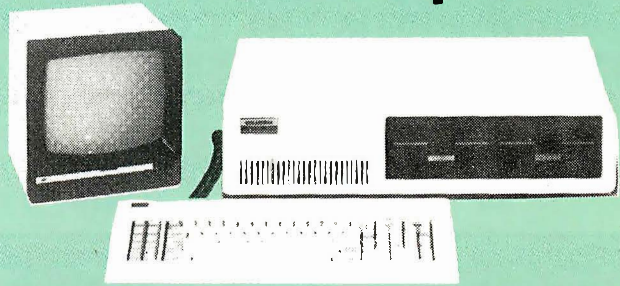
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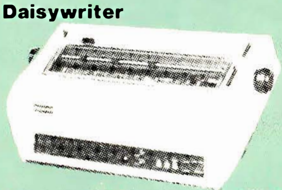
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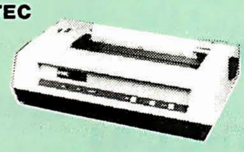
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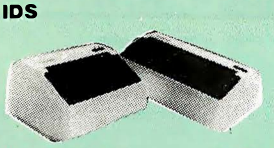
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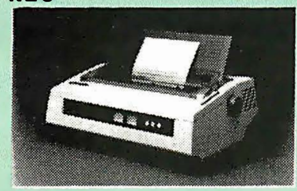


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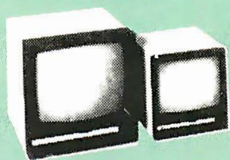
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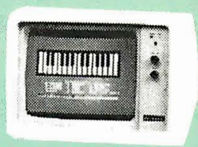


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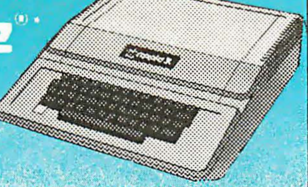
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Public Key Cryptography

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Cryptography, the art of concealing the meaning of messages, has been practiced for at least 3000 years. In the past few centuries, it has become an indispensable tool in the military affairs, diplomacy, and commerce of most major nations. During that time there have been many innovations, and cryptography has changed and grown to accommodate the increasingly complex needs of its users. Present techniques are very sophisticated and provide excellent message protection. Current developments in computer technology and information theory, however, are on the verge of revolutionizing cryptography. New kinds of cryptographic systems are emerging that have incredible properties, which appear to eliminate completely some problems that have plagued cryptography users for centuries. One of these new systems is public key cryptography.

In public key systems, as in most forms of cryptography, a piece of information called a key is used to transform a message into cryptic form. In conventional cryptography this key must be kept secret, for it can also be used to decrypt the message. In public key cryptography, however, a message remains secure even if its encryption key is publicly revealed. This unique feature gives public key systems great advantages over conventional systems.

This article deals with the theory and application of public key cryptography. It reviews the methods and problems of traditional cryptography and describes the remarkable concept and advantages of public keys. It also describes a real public key cryptosystem, showing examples of the encryption and decryption operations; and it attempts to clarify the concept of trap-door one-way functions, upon which public key systems are based.

Computers are essential for implementing many modern cryptosystems, including the one described here. Several BASIC-language programs (TRS-80) are included to illustrate algorithms used in this system. These can be used to experiment with the encryption, decryption, and derivation of small keys.

Conventional Cryptosystems

A cryptosystem must have two methods for transforming messages: a method of encryption, which renders messages unintelligible; and a method of decryption, for restoring them to their original forms. For simplicity, normal message text shall be called plaintext, and the encrypted form, ciphertext. Ciphertext messages may also be called cryptograms, or may just be called messages when it is clear that the encrypted form is meant.

To appreciate the significance of a public key system, we need to know some of the methods and problems of conventional cryptosystems. In a conventional system (see figure 1), a plaintext message is converted to a cryptogram by an encryptor and sent over a communication channel. While in transit, the cryptogram may be intercepted by someone other than the intended recipient. If it is encrypted well, it will be meaningless to the interceptor. At the receiving end, the cryptogram is converted back into plaintext by a decryptor. The encryptor and decryptor may be procedures executed by people or computers or may be specially constructed devices. In any case, they are both supplied with keys from a key source.

Cryptographic keys are analogous to the house and car keys we carry in our daily lives and serve a similar purpose. In many modern systems, each key is a string of digits. For example, keys defined by the Data Encryption Standard of the National Bureau of Standards consist of 64



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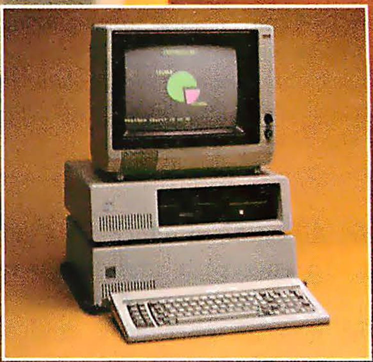
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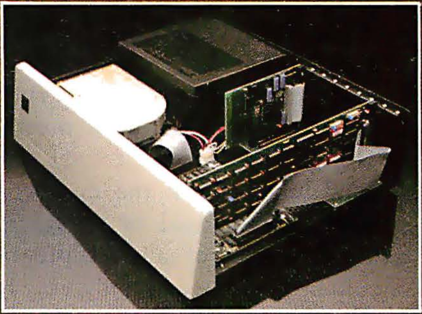
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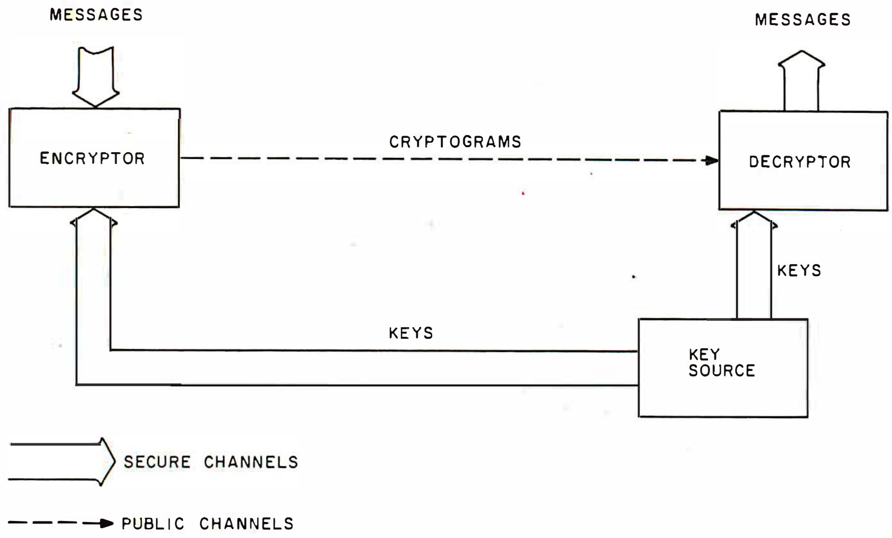


Figure 1: *A conventional cryptographic system. Encrypted messages (cryptograms) are sent over a public communication channel, while the keys needed for encryption and decryption are sent over secure channels, for example, via courier. The key source may be located at the encryptor or decryptor, in which case one of the secure channels is very short.*

binary digits, 56 of which are significant. To encrypt a message, a key and the message are somehow inserted into an encryptor, and the cryptogram that emerges is a jumble of characters that depends on both the message and the key. To decrypt the message, the correct key and the cryptogram are inserted into a decryptor, and the plaintext message emerges. In conventional systems, the correct key for decrypting a message is the same one used to encrypt it. Obviously, the keys used must be closely guarded secrets.

In a good system the number of possible keys should be very large, and decryption of any cryptogram should be possible with only very few of the keys, often with only one. These conditions make it impractical to try decrypting a message with one key after another until the one that reveals plaintext is found. The Data Encryption Standard provides more than 7×10^{16} keys (a 7 followed by 16 zeros), and there is some controversy over whether this number is sufficient!

The keys to be used are obtained from a key source, which selects them, perhaps randomly, from the large set of all usable keys. The key source may be located near the encryptor, near the decryptor, or elsewhere. But each key to be used must be made available to both the encryptor and the decryptor. Therein lies the most serious problem of conventional cryptosystems: some safe method must exist for distributing secret keys to the encryptor and the decryptor.

This problem is illustrated with a simple example: let's say you want to communicate privately with a friend named Mary. Many communication channels are available to you, none of which may be completely private: telephone, mail, and computer networks, for examples. You could send encrypted messages, but Mary could not read them without the keys. And you dare not send secret keys over these public channels. One of you must visit the other, so that you could agree on a key to use for future correspondence. But if your communication need was for only one private message exchange, it could be transacted during the visit, rendering the conventional cryptosystem unnecessary. Or if your communication need were immediate, a personal visit could cause an unacceptable delay. And if you need to communicate with several people, all the necessary visits could entail considerable expense. Most conventional cryptosystems, including the Data Encryption Standard system, have this problem. Public key cryptosystems, however, can avoid this problem entirely.

Public Key Systems

The concept of public keys may be one of the most significant cryptographic ideas of all time. A public key system has two kinds of keys: encryption keys and decryption keys. It may seem that having two kinds would make the key distribution problem worse, or at least no better. These keys, however, have remarkable, almost magical, properties:

- for each encryption key there is a decryption key, which is *not* the same as the encryption key
- it is feasible to compute a pair of keys, consisting of an encryption key and a corresponding decryption key
- it is not feasible to compute the decryption key from knowledge of the encryption key

Because of these properties, Mary and you can use a public key system to communicate privately without transmitting any secret keys. To set it up, you generate a pair of keys, and send the encryption key to Mary by any convenient means. It need not be kept secret. It can only encrypt messages—not decrypt them. Revealing it discloses nothing useful about the decryption key. Mary can use it to encrypt messages and send them to you. No one but you, however, can decrypt the messages (not even Mary!), as long as you do not reveal the decryption key. Figure 2 illustrates the flow of information in this situation, with Mary on the left and you on the right. To allow you to send private messages to her, Mary must similarly create a pair of keys, and send her encryption key to you.

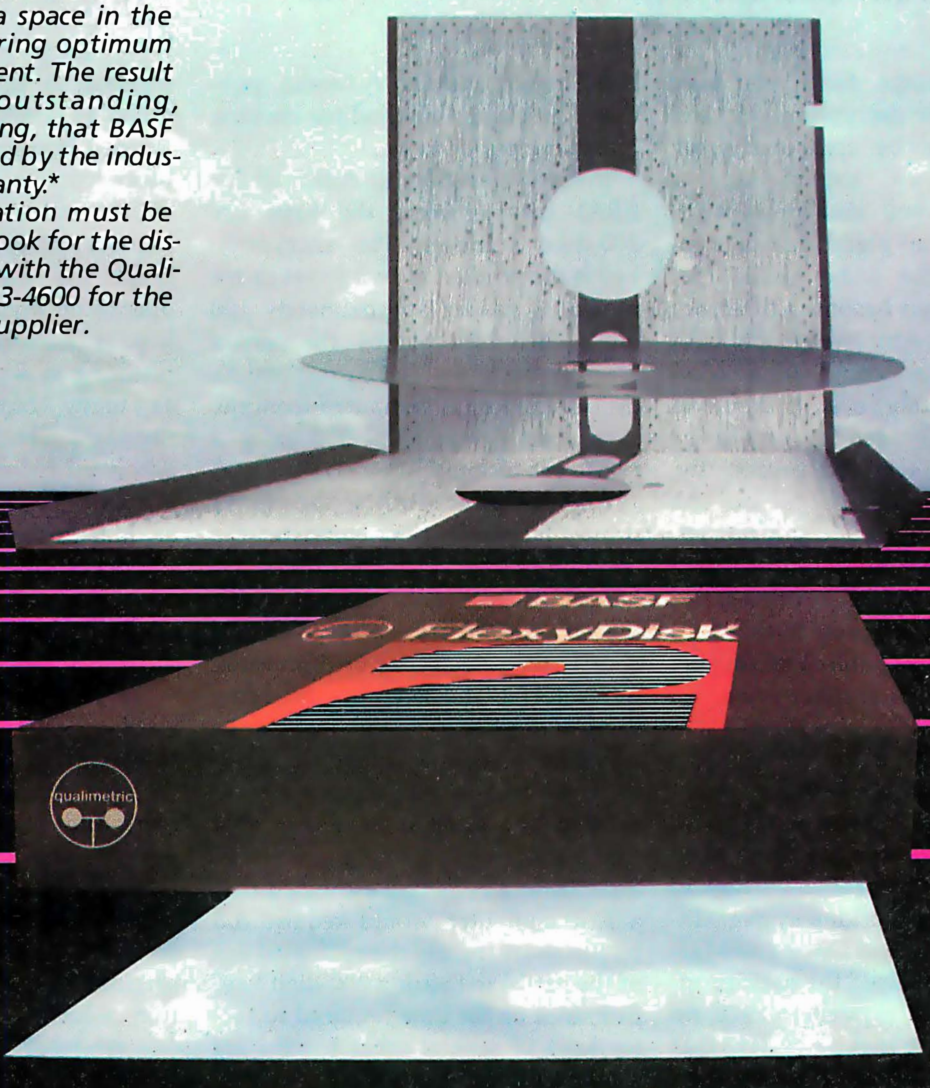
You can also go a step further. Since your encryption key need not be kept secret, you can make it public, for example, by placing it in a computer network public file. Once you have done so, anyone who wants to send you a private message can look up your public key and use it to

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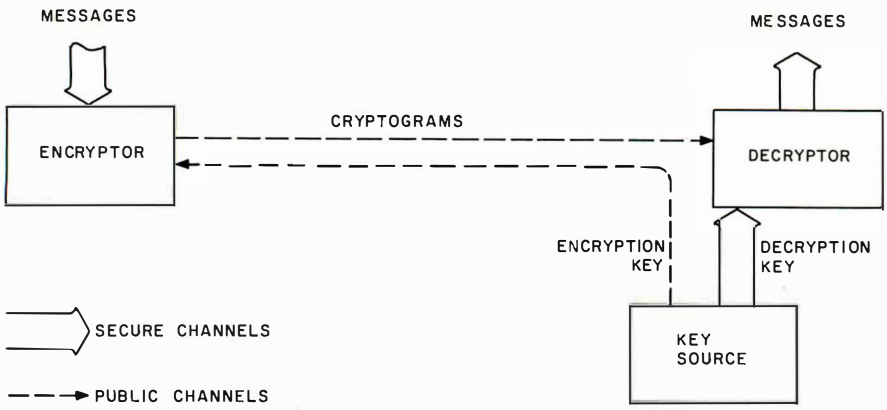


Figure 2: *A public key cryptographic system. Encryption keys can be safely sent over the ordinary communication channel because the information they contain cannot be used to decrypt messages. Decryption keys are created near the decryptor and are not sent anywhere else. Each person who expects to receive encrypted messages creates a key for encryption and a corresponding key for decryption and sends the encryption key to those who will originate the messages.*

Key Length (digits)	Factoring Time
50	3.9 hours
100	74 years
150	1.0 million years
200	3.8 billion years
250	5.9 trillion years

Table 1: *The time required to break the RSA public key system by factoring the key, for several different key lengths. These factoring times assume one computer operation per microsecond.*

encrypt a message. Since you need not transmit the decryption key, and since it cannot be computed from your public key, the message is secure. Only you can decrypt it. Other people can place their encryption keys in the same public file, which would thus become a directory of public keys. Any two people with directory entries could then communicate privately, even if they had no previous contact. It would be necessary, however, to protect the keys in such a file so that no one could change someone else's encryption key, for example, by substituting another encryption key. Fortunately, there is a way to protect the keys themselves with a public key cryptosystem, but that is another topic.

The RSA Cryptosystem

Now that the general concepts of public key cryptography have been examined, the next problem is how to design an actual working system. Indeed, when Whitfield Diffie and Martin Hellman conceived the basic properties of this cryptosystem in 1976, no one knew how to make a system that could employ them. The situation was similar to that of space travel in 1950. It was conceivable, but no one had accomplished it. In 1977, three researchers at the Massachusetts Institute of Technology, Ron Rivest, Adi Shamir, and Len Adleman, published an elegant method for creating and using public keys.

In the Rivest-Shamir-Adleman (or RSA) cryptosystem, the keys are 200-digit numbers. The encryption key is the product of two secret prime numbers, having approximately 100 digits each, selected by the person creating the keys. The corresponding decryption key is computed from the same two prime numbers, using a nonsecret formula.

Anyone who knows the secret prime numbers can compute the decryption key, but the primes are hidden because only their product, the encryption key, is revealed. Of course, the primes may be discovered by factoring the key, but factoring such a number is about as easy as traveling to Alpha Centauri, especially if the person who constructs the number has done it in a way that discourages factoring. Rivest, Shamir, and Adleman estimated that a fast computer would require 3.8 billion years (nearly the estimated age of the earth) to factor a 200-digit key. Estimates of the time required to factor keys of several other lengths are shown in table 1.

Before encryption, a message is converted into a string of numbers. This step is common in cryptosystems, as it is in computers and communication systems. Next, the message is subdivided into blocks, much as computer text files are subdivided into records or sectors. Each block contains the same number of digits, and is treated as one large number during encryption. To encrypt the message, an arithmetic operation involving the encryption key is performed on each block, resulting in a cryptogram containing as many blocks as the original message. The arithmetic operation, described below, is the same for all blocks. To decrypt, the inverse arithmetic operation, which requires the decryption key, is performed on each block of the cryptogram. The result is the original message in its numerical form.

As you can imagine, it would be cumbersome to illustrate these operations with 200-digit numbers, so the detailed descriptions below use small keys and messages; otherwise, the operations shown are the same as those used in a full-size RSA system. Also, the encryption method described here is actually a subset of the original RSA method. This modification, which is due to Donald Knuth (see reference 3), uses the basic RSA technique, while lessening somewhat the number of computations involved. (For more detailed information, the reader should refer to the original Rivest-Shamir-Adleman paper, shown as reference 5.)



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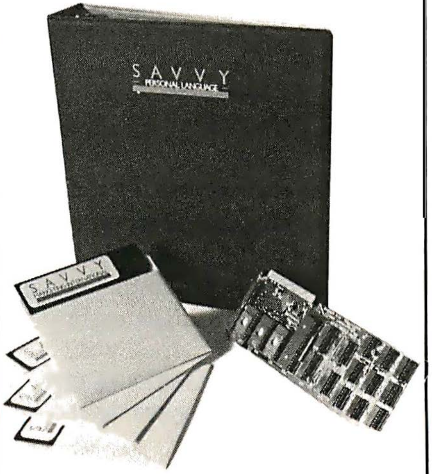
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Arithmetic with a Modulus

The Rivest-Shamir-Adleman cryptography system uses arithmetic modulo n in encoding, decoding, and key selection. Because arithmetic modulo n is almost the same as ordinary arithmetic, it is easy to use.

To add or multiply modulo n, first add or multiply in the usual way. Then divide the result by n, and use the remainder for the final answer. For example, in arithmetic modulo 5, 3 + 4 = 2, because 3 + 4 is ordinarily 7, and 7 divided by 5 leaves a remainder of 2. This equation is usually written

$$(3 + 4) \bmod 5 = 2$$

where the notation "mod 5" indicates that arithmetic modulo 5 is being performed. Using this notation:

$$(4 \times 4) \bmod 5 = 1$$

since 4×4 = 16, and 16 divided by 5 leaves a remainder of 1.

The number n is called the modulus, and may be any positive integer. All answers in arithmetic modulo n are smaller than n, but are never negative. For example, when n is 5, every correct answer is 0, 1, 2, 3, or 4. If the initial result of addition or multiplication is less than n, the division step is unnecessary.

When performing a chain of operations, such as

$$(2 \times 3 \times 4) \bmod 5 = 4$$

the division step may be performed after each operation or at the end. The answer will be the same. When performing a chain of multiplications, it is best to perform the division step after every multiplication to keep the intermediate results from growing larger and larger. This is especially important where the intermediate results could overflow a computer's storage area.

Several common devices inherently perform arithmetic with a modulus. For example, most automobile odometers use a modulus of 100,000. If such an odometer reads 99,987 at the start of a 45-mile trip, it will read 32 at the destination; in the notation of arithmetic modulo n:

$$(99987 + 45) \bmod 100000 = 32$$

Computers are easily programmed to perform arithmetic modulo n. In BASIC, one extra statement is required for each arithmetic operation. For example, to calculate (A×B) mod n:

```
500  X = A*B
510  X = X - INT(X/N)*N
```

*Many interpreters allow placing both statements on the same line. INT(X/N) is the quotient that would result from division of X by N; INT(X/N)*N is the quotient times the divisor; and X − INT(X/N)*N is the remainder.*

In this article, an encryption operation is described that requires that a number be cubed modulo n. This BASIC subroutine computes B =(A³) mod n:

```
500 REM  COMPUTE B = (A*A*A)
    MOD N
510 B = A*A
520 B = B - INT(B/N)*N:
    REM  MOD N
530 B = B*A                  :
    REM  (A*A)*A
540 B = B - INT(B/N)*N:
    REM  MOD N
550 RETURN
```

When multiplying integers, the number of digits in the result is usually the sum of the numbers of digits in the operands. If the result has more digits than the interpreter uses in its variables, the computed result will not be exact. Use double-precision variables, if they are available. Exact results will be obtained if the number of digits in the modulus is no more than half the number of digits used by the interpreter, and all operands are smaller than the modulus, which is usually the case.

How to Encrypt

While the encryption and decryption operations are normally performed by a computer program, I will describe them as if you were performing them by hand. Normally, the only manual operation required is entering the message to be encrypted.

Suppose you wish to encrypt the message

MARY HAD A LITTLE LAMB.

Once entered into a computer, the message will be in numerical form, frequently in ASCII (American Standard Code for Information Interchange). In ASCII, this message is

77 65 82 89 32 72 65 68 32
65 32 76 73 84 84 76 69 32
76 65 77 66 46

This is not yet encrypted, of course. It is merely written as a computer might represent it (all the numbers in this article are decimal). Group the message into blocks with six digits each:

776582 893272 656832 653276
738484 766932 766577 664600

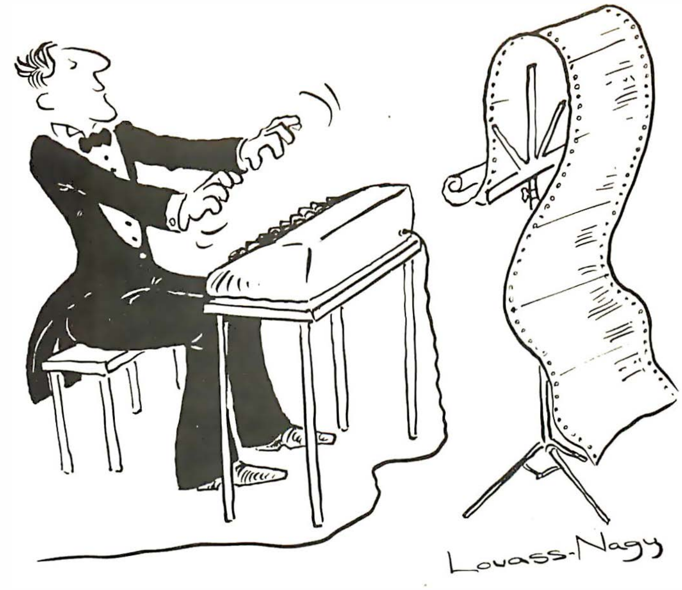
Each block except the last consists of three consecutive characters from the ASCII representation above. The last block consists of the last two characters plus two zeros added at the right to make the final block as long as the rest. Digits added for this purpose may have any value.

Suppose that the encryption key, usually called n, is 94815109. This is the product of two prime numbers. To encrypt the message, treat each block as a number, and cube it modulo n (see the text box "Arithmetic with a Modulus"). For example, to encrypt the first block of the message:

$$(776582 \times 776582 \times 776582) \bmod 94815109 = 71611947$$

Performing the cubing operation on all eight blocks produces the cryptogram

71611947 48484364 03944704
03741778 61544362 35331577
88278091 50439554



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Arithmetic modulo n is a fundamental part of the RSA system. It is also used in decryption and creating keys. Most of us have used arithmetic modulo n, although perhaps we didn't call it that. For instance, arithmetic modulo 12 is frequently used in calculations related to keeping time. The text box "Arithmetic with a Modulus" reviews the mechanics.

Almost any method may be used to convert the text to numbers. It would have worked just as well to use A=1, B=2, . . . Z=26, but the ASCII code is already in wide use, and it includes numbers for spaces and punctuation. The block length should be almost equal to the key length, because making it long minimizes the number of blocks per message. When considered as a number, however, no block should be as large as the key. For the above key, no block should be larger than 94815108. Making the block length slightly less than the key length ensures that this requirement is met. Of course, with full-length keys, there will be about 100 characters per block.

Listing 1 is a BASIC program that uses the above key to encrypt a line of text. Two lines of the program (670 and 680) perform the encryption. The rest deal with input, formatting, and printing. If desired, the encryption key in line 220 may be changed; use a key with seven or eight digits, or reduce the number of characters per block (line 210).

The programs in listings 1 through 4 were written for the TRS-80 BASIC interpreter, which is capable of 16-digit precision. They may be adapted for use with other interpreters, and I have tried to structure and annotate them well enough to make them easy to modify.

How to Decrypt

Since the RSA system is a public key system, the decryption key, usually called d, differs from the public encryption key. For the above encryption key, d is 63196467. Knowing the value of d, you can decrypt the message by raising each cryptogram block to the power d, modulo n. That is, if a cryptogram block is C, you must compute $(C^d) \bmod n$. For example, to decrypt the first block of the above cryptogram:

$$(71611947^{63196467}) \bmod 94815109 = 776582$$

converts this block back to the first three ASCII codes of the original message. Each of the remaining blocks is decrypted in the same way.

Fortunately, raising a number to a large power does not require performing a comparable number of multiplications. One efficient algorithm is a variation of the "Russian Peasant Method" of multiplication (see reference 4). It computes $M = (C^d) \bmod n$, as follows:

1. Let $M = 1$.
2. If d is odd, let $M = (M \times C) \bmod n$.
3. Let $C = (C \times C) \bmod n$.
4. Let d = integer part of $d/2$.
5. If d is not zero, repeat from step 2; otherwise, terminate with M as the answer.

To raise a number to the power 63196467, this algorithm executes its loop (steps 2 through 5) 26 times. It is employed as a subroutine in the BASIC-language decryption program of listing 2. Line 200 contains the keys, which may be changed, if desired. Lines 340 through 380 execute the algorithm.

Text continued on page 210

Listing 1: *A program in BASIC (TRS-80) to demonstrate the encryption process described in the text. Lines 670-680 perform the encryption. When the program prompts you, type the text to be encrypted. The program will then print the text in numerical form, followed by the cryptogram. Use uppercase letters only.*

```
100 '=========================================================
110 ' ENCRYPT MESSAGES, USING A MINIATURE VERSION OF THE
120 ' RIVEST-SHAMIR-ADLEMAN PUBLIC KEY CRYPTOSYSTEM.
130 '
140 ' PROMPT FOR THE MESSAGE TO BE ENCRYPTED, PRINT THE
150 ' NUMERIC FORM OF THE MESSAGE, AND PRINT THE CRYPTOGRAM.
160 '=========================================================
170 ' DEFINE PARAMETERS.
180 '
190 DEFDBL C,M,N                       ' C, M, AND N HAVE 16 DIGITS
200 DIM M(100)                         ' MESSAGE BLOCKS
210 CHRS = 3                           ' CHARACTERS PER BLOCK
220 N = 94815109                       ' ENCRYPTION KEY, OR MODULUS
230 '---------------------------------------------------------
240 ' GET THE MESSAGE FROM THE USER.
250 '
260 PRINT : M$ = ""
270 INPUT "MESSAGE"; M$                ' MESSAGE FOR ENCRYPTION
280 IF M$ = "" THEN END                ' STOP IF NOTHING IS ENTERED
290 PRINT
300 '---------------------------------------------------------
310 ' ADD ZEROS TO MESSAGE, IF NECESSARY, TO MAKE ITS LENGTH
320 ' A MULTIPLE OF THREE (AN EVEN NUMBER OF BLOCKS).
330 '
340 L = LEN(M$)                        ' LENGTH OF MESSAGE
350 Q = INT(L/CHRS)                    ' NUMBER OF COMPLETE BLOCKS
360 R = L - Q * CHRS                   ' LENGTH OF PARTIAL BLOCK
370 IF R > 0 THEN M$ = M$ + CHR$(0) : GOTO 340 ' ADD A ZERO?
380 '---------------------------------------------------------
390 ' CONVERT THE MESSAGE TO NUMERIC FORM, AND PRINT IT.
400 '
410 FOR I=0 TO Q-1                     ' I IS THE BLOCK NUMBER
420   M(I) = 0                         ' CONVERT BLOCK I TO NUMERIC
430   FOR J=1 TO CHRS                    ' FOR EACH CHAR IN BLOCK
440     A = ASC(MID$(M$,3*I+J,1))        ' CONVERT TO NUMBER
```

Listing 1 continued on page 208

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Listing 1 continued:

```
450      M(I) = M(I) * 100             ' SHIFT BLOCK LEFT
460      M(I) = M(I)+ A                ' ADD THE CHARACTER
470    NEXT J
480    PRINT M(I);                    ' PRINT THE BLOCK
490 NEXT I                            ' DO THE NEXT BLOCK
500 PRINT : PRINT
510 '-------------------------------------------------------------
520 ' ENCRYPT THE MESSAGE, AND PRINT THE CRYPTOGRAM.
530 '
540 PRINT "CRYPTOGRAM:" : PRINT
550 FOR I=0 TO Q-1                    ' I IS THE BLOCK NUMBER
560    M = M(I)
570    GOSUB 670                      ' ENCRYPT THE BLOCK
580    PRINT C;                       ' PRINT IT
590 NEXT I                            ' DO THE NEXT ONE
600 PRINT
610 '-------------------------------------------------------------
620 GOTO 260                          ' RUN THE PROGRAM AGAIN
630 '-------------------------------------------------------------
640 ' SUBROUTINE.  ENCRYPT ONE MESSAGE BLOCK.
650 ' COMPUTE C = (M^3) MOD N.
660 '
670 C = M * M : C = C - INT(C/N) * N     ' (M * M) MOD N
680 C = C * M : C = C - INT(C/N) * N     ' (M * M * M) MOD N
690 RETURN
700 '=============================================================
```

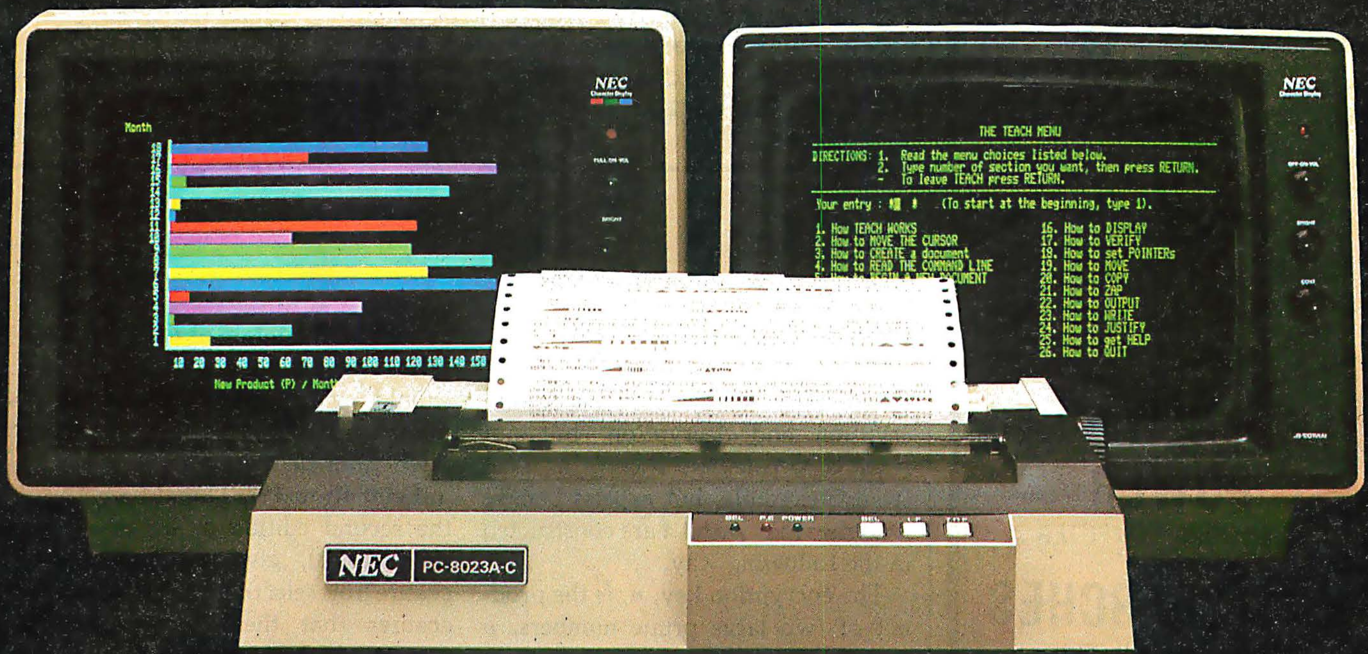
Listing 2: *A program in BASIC (TRS-80) to demonstrate the decryption process described in the text. Lines 340-390 decrypt one block of a cryptogram by raising it to a power. The program asks for a cryptogram block to be decrypted. Several seconds later, it prints the decrypted characters in ASCII. If you enter 0, the program will terminate.*

```
100 '=============================================================
110 ' DECRYPT MESSAGES, USING A MINIATURE VERSION OF THE
120 ' RIVEST-SHAMIR-ADLEMAN PUBLIC KEY CRYPTOSYSTEM.
130 '
140 ' PROMPT FOR THE CRYPTOGRAM BLOCK TO BE DECRYPTED, AND
150 ' DECRYPT AND PRINT THE MESSAGE BLOCK, IN NUMERIC FORM.
160 '=============================================================
170 ' DEFINE PARAMETERS.
180 '
190 DEFDBL C,D,M,N                    ' DOUBLE PRECISION
200 N = 94815109 : D = 63196467       ' KEYS
210 '-------------------------------------------------------------
220 ' MAIN PROGRAM LOOP.
230 '
240 INPUT "CRYPTOGRAM BLOCK"; C       ' USER ENTRY
250 IF C = 0 THEN END                 ' STOP IF NO ENTRY
260 GOSUB 340                         ' DECRYPT BLOCK
270 PRINT M                           ' MESSAGE BLOCK
280 GOTO 240                          ' REPEAT
290 '-------------------------------------------------------------
300 ' SUBROUTINE.  DECRYPT C, CRYPTOGRAM BLOCK.
310 ' COMPUTE M = (C^D) MOD N.  USE MODIFIED RUSSIAN PEASANT
320 ' ALGORITHM (BYTE, OCTOBER 1981, PAGE 376).
330 '
```

Listing 2 continued on page 210

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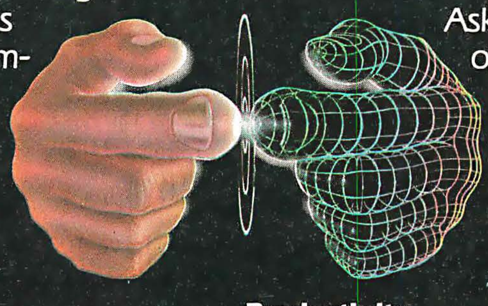
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Listing 2 continued:

```
340 D1 = D : M = 1
350 IF D1/2 = INT(D1/2) GOTO 370          ' IF D1 IS EVEN, SKIP
360 M = M * C : M = M - INT(M/N) * N      ' M = (M * C) MOD N
370 C = C * C : C = C - INT(C/N) * N      ' C = (C * C) MOD N
380 D1 = INT(D1/2) : IF D1 > 0 GOTO 350
390 RETURN
400 '==============================================================
```

How to Derive Keys

Earlier, I said that it is feasible to derive a pair of keys, n and d, for encryption and decryption, but not feasible to calculate d from n. That seems incredible, but experts believe it is true when n and d are constructed in the following way.

The encryption key, n, is the product of two large prime numbers, p and q:

$$n = pq \qquad (1)$$

The decryption key, d, is calculated from p and q by

$$d = [\ 2(p-1)(q-1) + 1\ ]/3 \qquad (2)$$

Although n is made public, p and q remain secret. If n is sufficiently large, say 200 digits, it is practically impossible for anyone to factor it and discover the values of p and q; and without knowing p and q, it is equally difficult to compute d.

For the encryption and decryption examples given earlier, the keys were constructed as follows:

prime number, $p = 7151$
prime number, $q = 13259$
encryption key, $n = 7151 \times 13259$
$= 94815109$
decryption key, $d = (2 \times 7150 \times 13258 + 1)/3$
$= 63196467$

Because p and q may have 100 or more digits in an operational RSA system, their selection requires computer assistance. The following three restrictions apply to how they should be chosen. First, neither $p-1$ nor $q-1$ must be divisible by 3, or the decryption operation will not work correctly. Second, $p-1$ and $q-1$ should both contain at least one large prime factor. Third, the ratio p/q should not approximate a simple fraction, e.g., ⅔, ¾, etc. These last two restrictions help ensure that n will be difficult to factor. Donald Knuth, in the second edition of his book (see reference 3), gives a detailed procedure for selecting p and q, which ensures that these restrictions are met. While the procedure described is for constructing 250-digit keys, it is applicable to other key lengths.

Enough keys are available for everyone. The number of 250-digit keys constructible with Knuth's procedure is much greater than 10^{200}. For comparison, the number of atoms in the known universe is about 10^{80}.

To create a different pair of seven- or eight-digit keys, find primes p and q such that neither $p-1$ nor $q-1$ is divisible by 3, and the product $n = pq$ is a seven- or eight-digit number. Then calculate d from formula (2). Divisibility by 3 is easily checked by casting out 3s, and the BASIC programs described below are helpful in finding prime numbers.

How to Find Large Prime Numbers

To find a large prime number, select a random odd number of the required size and determine whether it is prime. If it is not, increase it (or decrease it) by 2 and try again, repeating until finding a prime. It is not necessary, however, to attempt to factor a number to determine whether it is prime.

To test whether a number n is prime, select any number greater than 1 and smaller than n, say x, and calculate

$$y = (x^{n-1}) \bmod n$$

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If y is not equal to 1, n is not prime. But if $y = 1$, n *may* be prime, and further testing is required. Repeat the test using another value of x. If this test is performed with many different values of x, and if $y = 1$ for all the test cases, n is probably prime. Listing 3 is a BASIC program that uses 10 values of x to test a number for primality. If the program says the number is not prime, it is not prime. But if the program says the number is probably prime, there is a small chance that it is not.

What is the probability that this program will make an error? I don't know, but it illustrates a class of programs, some of which are very good. Knuth (reference 3, page 375) presents one that is slightly more complicated, for which the odds against an error are a million to one when 10 values of x are used for testing, and are a million million to one when 20 values are used. For serious work I would use the more complicated program, but the one presented here illustrates the process of testing without factoring—and it doesn't seem bad. It has not made an error in several hundred trials.

Listing 4 is a BASIC program that searches for a prime number using the same test method as the previous program. The program will begin with the number you enter and search downward until it finds a probable prime, which it will identify. If you enter 99999999, it will find the largest eight-digit prime. This program helps to find primes for constructing small keys like the ones above.

Listing 3: *A program in BASIC (TRS-80) to test whether a number is prime. This program demonstrates a primality test that does not attempt to factor the number being tested. For very large numbers, it is much faster than factoring.*

```
100 '=====================================================
110 ' TEST WHETHER A NUMBER IS PRIME.
120 ' USE PROBABILISTIC TEST BASED ON FERMAT'S THEOREM.
130 ' SEE KNUTH, "SEMINUMERICAL ALGORITHMS".
140 '
150 ' PROMPT FOR NUMBER, TEST IT, AND PRONOUNCE VERDICT.
160 '=====================================================
170 ' DEFINE PARAMETERS.
180 '
190 DEFDBL N,P,X,Y                  ' DOUBLE PRECISION
200 K = 10                          ' NUMBER OF TEST CASES
210 '-----------------------------------------------------
220 ' GET A NUMBER TO BE TESTED.  CHECK THE SIZE.
230 '
240 PRINT
250 INPUT "NUMBER"; N               ' GET A NUMBER TO TEST
260 IF N < 3 THEN END
270 IF N > 99999999 THEN PRINT "TOO BIG" : GOTO 240
280 '-----------------------------------------------------
290 ' DETERMINE WHETHER N IS PRIME.
300 '
310 PRINT "TEST NUMBER: ";
320 FOR I=1 TO K                    ' TEST CASES
330     X = 2 + INT((N-2)*RND(0))       ' TEST VALUE
340     PRINT X;
350     GOSUB 490                       ' PERFORM TEST
360     IF Y <> 1 GOTO 380              ' NOT PRIME?
370 NEXT I
380 PRINT : PRINT                   ' NOT PRIME IF Y <> 1
390 '-----------------------------------------------------
400 ' PRINT THE VERDICT.
410 '
420 IF Y = 1  THEN PRINT N; "IS PROBABLY PRIME."
430 IF Y <> 1 THEN PRINT N; "IS NOT PRIME."
440 '-----------------------------------------------------
450 GOTO 240                        ' RUN THE PROGRAM AGAIN
460 '-----------------------------------------------------
470 ' SUBROUTINE.  COMPUTE Y = [X^(N-1)] MOD N.
480 '
490 Y = 1 : P = N-1
500 IF P/2 = INT(P/2) GOTO 520        ' IF P IS EVEN, SKIP
510 Y = Y * X : Y = Y - INT(Y/N) * N ' (Y * X) MOD N
520 X = X * X : X = X - INT(X/N) * N ' (X * X) MOD N
530 P = INT(P/2) : IF P > 0 GOTO 500
540 RETURN
550 '=====================================================
```

One-Way Functions and Trap-Doors

Public key cryptosystems derive their unusual properties from mathematical functions called trap-door one-way functions, which are useful because they can act as ordinary functions or as one-way functions.

One-way functions are like one-way streets. The ordinary cube function, $B = A^3$, resembles a one-way function in that it is easier to calculate B, given A, than it is to calculate A, given B. The latter calculation, the cube-root function, is called the inverse of the cube function. The inverse of an automobile would convert smog to gasoline. A mathematical function is said to be one-way if it is much more difficult to compute the inverse than to compute the function itself. To qualify as a one-way function, the inverse must be very difficult to compute, even by machine. A function that could be computed in a few seconds, for which computing an inverse required thousands of years, would fit the definition.

To create a public key cryptosystem, a trap-door one-way function is used. It is easy to compute an inverse of a trap-door one-way function, but

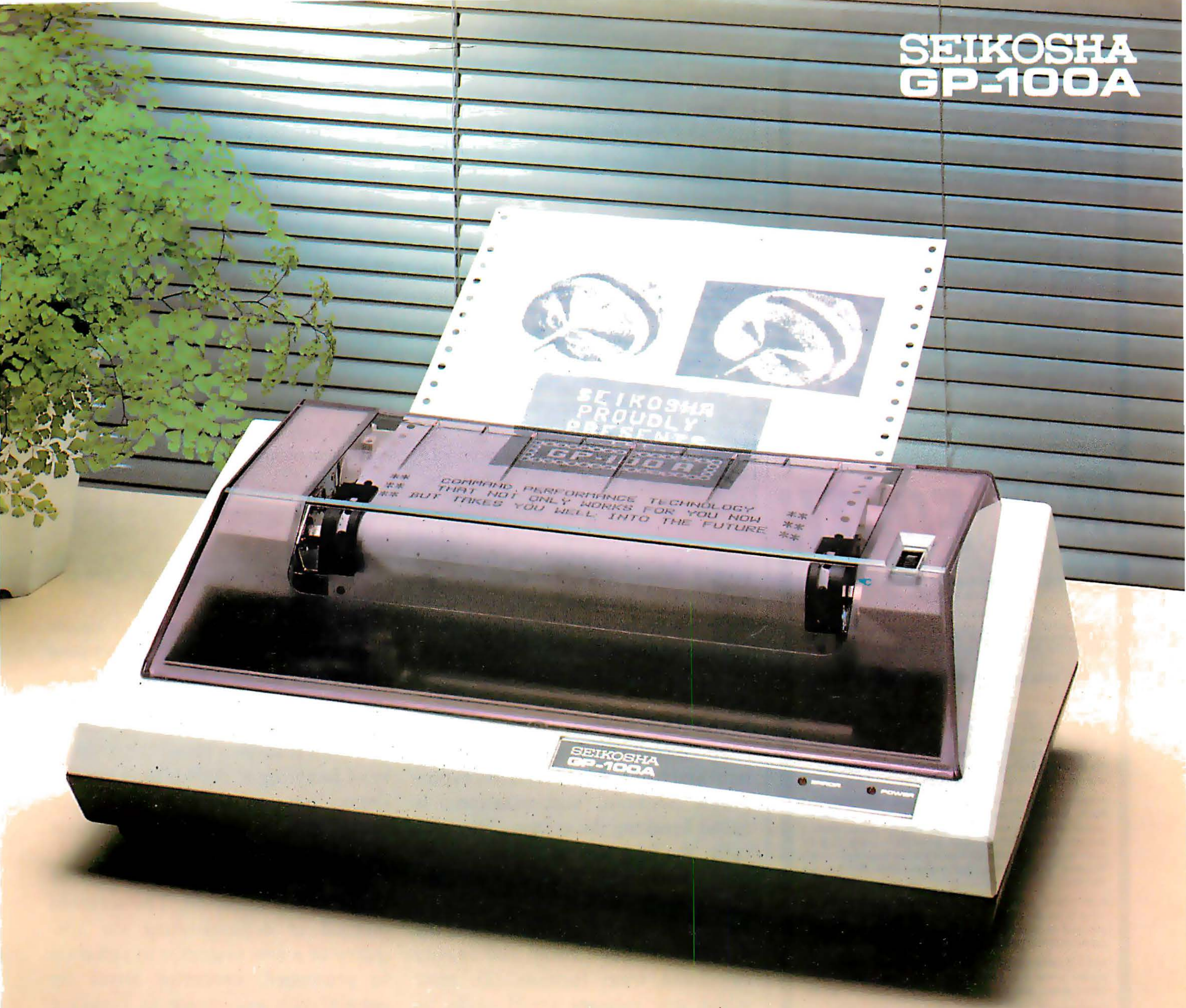
it can be very difficult to determine how. Computing an inverse can take millions of years because finding out how to do it can take that long. If the method is known, computing an inverse may take only a few seconds. This is a completely different situation than that created by a one-way function, for which there is no easy way to compute an inverse. When a trap-door one-way function is being constructed, the person constructing it has access to information, called trap-door information, that reveals how to compute inverses. Once the function is constructed, the trap-door information is hidden so well that it can take millions of years to find.

The Knuth modification of the RSA system encryption function, cubing a number modulo n, is a trap-door one-way function. Its inverse function is the cube root modulo n. In arithmetic modulo n, "cube root" is defined as in ordinary arithmetic: if B is the cube of A, then A is the cube root of B. Notice that this definition does not say how to compute cube roots (in either kind of arithmetic). If you know how to compute cube roots modulo n, you know how to decrypt messages. In modulo n arithmetic, the cube root of B is computed by raising B to some power d, modulo n. But knowing this doesn't help unless you know the value of d. And d can be computed by formula (2) if n has two factors (p and q), and $p-1$ and $q-1$ are not divisible by 3. If you construct the modulus, n, you know p and q, and can therefore calculate the value of d. Knowing d, you can compute cube roots; in other words, decrypt cryptograms. The values of p and q are hidden from other people by the difficulty of factoring n. They are deprived of the value of d, and therefore cannot compute cube roots. Hence, they cannot decrypt cryptograms created by cubing modulo n. In the RSA system, the value of d is the trap-door information that reveals how to compute inverses (cube roots). You might think of p and q as comprising a trap-door through which the value of d is obtained. Factoring n is analogous to finding the trap-door, but it is very difficult to do.

Listing 4: *A program in BASIC (TRS-80) that searches for a prime number. It illustrates the search technique and may be used to help construct small keys for the public key cryptosystem described in the text. Enter any number of eight digits or fewer, and the program will find a prime number that does not exceed the number entered.*

```
100 '==========================================================
110 ' FIND A PRIME NUMBER NO LARGER THAN THE NUMBER ENTERED.
120 ' USE PROBABILISTIC TEST BASED ON FERMAT'S THEOREM.
130 ' SEE KNUTH, "SEMINUMERICAL ALGORITHMS".
140 '==========================================================
150 ' DEFINE PARAMETERS.
160 '
170 DEFDBL N,P,X,Y                  ' DOUBLE PRECISION
180 K = 10                          ' NUMBER OF TEST CASES
190 '----------------------------------------------------------
200 ' GET A NUMBER TO BE TESTED.  CHECK THE SIZE.
210 '
220 PRINT
230 INPUT "NUMBER"; N               ' GET A NUMBER TO TEST
240 IF N < 3 THEN END               ' STOP IF SMALL NUMBER
250 IF N > 99999999 THEN PRINT "TOO BIG" : GOTO 220
260 '----------------------------------------------------------
270 ' DETERMINE WHETHER THE NUMBER ENTERED IS EVEN.
280 ' IF SO, SUBTRACT ONE.
290 '
300 IF N/2 = INT(N/2) THEN N = N - 1
310 '----------------------------------------------------------
320 ' PRINT N, THEN DETERMINE WHETHER IT IS PRIME.
330 '
340 PRINT N;
350 FOR I=1 TO K                              ' TEST CASES
360     X = 2 + INT((N-2)*RND(0))             ' TEST VALUE
370     GOSUB 520                             ' PERFORM TEST
380     IF Y <> 1 GOTO 400                    ' NOT PRIME?
390 NEXT I
400 REM
410 '----------------------------------------------------------
420 ' IF N IS PRIME, TERMINATE THE PROGRAM.  OTHERWISE,
430 ' DECREASE IT BY TWO, AND TRY AGAIN.
440 '
450 IF Y = 1 THEN PRINT "IS PROBABLY PRIME." : END
460 PRINT "NO." : N = N - 2 : GOTO 340
470 '----------------------------------------------------------
480 GOTO 220                        ' RUN THE PROGRAM AGAIN
490 '----------------------------------------------------------
500 ' SUBROUTINE.  COMPUTE Y = [X^(N-1)] MOD N.
510 '
520 Y = 1 : P = N-1
530 IF P/2 = INT(P/2) GOTO 550                ' IF P IS EVEN, SKIP
540 Y = Y * X : Y = Y - INT(Y/N) * N          ' (Y * X) MOD N
550 X = X * X : X = X - INT(X/N) * N          ' (X * X) MOD N
560 P = INT(P/2) : IF P > 0 GOTO 530
570 RETURN
580 '==========================================================
```

Other trap-door one-way functions undoubtedly exist, and these could be the foundations for other public key cryptosystems. For each of these systems, the same principles would apply. The creator of the system parameters would have access to certain trap-door information, which



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Editor's Note: *Recently, a software product became available that allows Z80 system owners to take advantage of the benefits offered by public key cryptography in their private correspondence. Called The Protector (from Standard Software of Randolph, Massachusetts; list price: $165), the new system uses a 77-digit key. On a 4-MHz Z80 microcomputer running under the CP/M operating system, message encryption and decryption take about one minute plus the necessary disk access time. The time needed to generate the encryption and decryption keys ranges from 15 minutes to 4 hours. The memory requirement is 38K bytes.*

Although the 77-digit key is much shorter than the 200-digit key proposed for the full-size Rivest-Shamir-Adleman system, the key may be more than adequate for most applications. The author of the system, Charles Merritt of PKS Inc., has received estimates of the time needed to break the system ranging from three uninterrupted days on a Cray-1 to one year.

*When asked about the people who were using the system, Mr. Merritt replied that he had not heard from any of them. Apparently, they also want to keep their identities secret. . . .***R. M.**

would reveal how to compute inverses. For everyone else, the trapdoor would be hidden, and for them the encryption function would be, in effect, a one-way function.

Is the RSA System Unbreakable?

Successfully analyzing a cryptosystem, and being able to read its cryptograms without authorization, is called breaking the system. Theoretically, the RSA system can be broken by a determined analyst. Factoring the encryption key, or modulus, would do the trick, for then the decryption key could be easily calculated from formula (2), after which any message could easily be decrypted. However, factoring a key of the recommended length and construction does not seem feasible. Knuth gives a procedure for constructing a 250-digit key and considers it inconceivable at this time that such a key could be factored. Experts acknowledge that a breakthrough in the art of factoring large numbers would render the RSA system worthless but consider such a breakthrough extremely unlikely. Apparently, factoring large numbers is not a new problem, but one that expert mathematicians have attacked for centuries, and it is known to be very difficult.

Another way to break the system is to determine the value of d without factoring n. Although you can approach this problem in several ways, experts believe that none of them are likely to be fruitful.

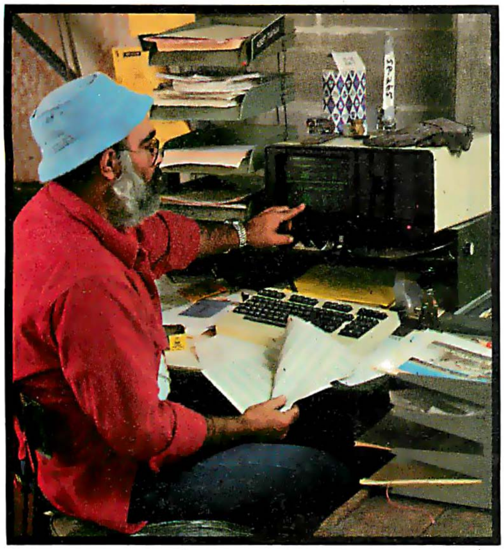
Yet another method of breaking the system is to learn how to compute cube roots modulo n without knowing the value of d. Less seems to be known about the difficulty of doing this than is known about the difficulty of factoring n. At this time, no one knows how to compute such cube roots in a reasonable time without knowing d.

Any new cryptosystem should be viewed with suspicion. The accepted method of demonstrating the adequacy of a new system is to subject it to prolonged, concerted attack by people with experience in breaking other systems. If the new system proves resistant to such an attack, it may tentatively be considered secure. The process of validation is continuing, but a fairly large number of preliminary studies done so far indicate that the system is quite secure.

Digital Signatures

Very closely related to public key cryptography is the concept of digital signatures. One problem with corresponding electronically, such as via a computer network, is that messages can be easily *forged*—you usually cannot be certain that the sender of a received message is actually the person claimed in the message. A public key cryptosystem, however, can be used to provide positive identification of any sender who has a public key

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Late Developments

Ron Rivest, one of the authors of the RSA public key cryptosystem, reports that it is presently finding commercial application in the transmission of keys for the U. S. Data Encryption Standard, a conventional system that can process information at a much faster rate. He and the other authors of the system are now at work producing a single-chip implementation of the system that can be used on a microprocessor bus, which should be able to process about 150 characters per second.

In a related item, Adi Shamir, another of the RSA authors, claims to have broken a rival public key system called the Knapsack System. Shamir's report, however, remains to be interpreted, and some variations of the Knapsack technique may still be usable. This system, developed by Ralph Merkle and Martin Hellman, is based on a well-known problem of determining which numbers of a given set of numbers were added together to produce a given sum.

on record. If, for example, Mary has filed a public key in some public access file, she can digitally sign a message to you by *decrypting* it with her private key before transmitting it. After receiving the message, you (or anyone else) can read the message by *encrypting* it with Mary's public encryption key. The process is essentially the reverse of the cryptosystem: the message is first decrypted and then encrypted, and anyone can reveal the message, but only Mary with her secret decryption key can create it.

In addition, messages using digital signatures can be subsequently encrypted with *another* key. After Mary decrypts her message to you with her secret decryption key, she can then *encrypt* it with your public encryption key. The result is a message that only Mary could have created, and only you can read!

Messages with digital signatures have other interesting and useful properties and may be used to advantage with other (non-PKC) cryptosystems. These properties and applications might easily justify an article on digital signatures alone.

Summary

This article has described the principles of public key cryptosystems. One example has been given, the Rivest-Shamir-Adleman system. We have seen how keys are constructed and used, and have at our disposal four BASIC programs for further experimentation. These programs may also be useful as models for assembly-language programs that could manipulate larger numbers and run faster. We have seen that the RSA cryptosystem provides public keys in more than astronomical quantities and that it is believed to be unbreakable.

Several questions come to mind: Is a personal computer powerful enough to run a full-size RSA system? How long would a small computer take to construct a 200-digit key? Or even a 100-digit key? How long would it take to decrypt a medium-length message?

Regardless of the answers to these questions, the prospects are good for using public key systems with small computers. New computer models appear almost monthly, and their performance is improving rapidly. The theoretical work that gave birth to the RSA system is also proceeding at a rapid pace, and we can expect new and different public key systems to result from that work. Some of these may be suitable, perhaps even optimized, for small machines, and the prospects are exciting.■

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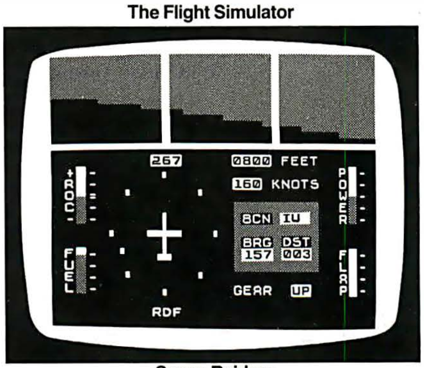
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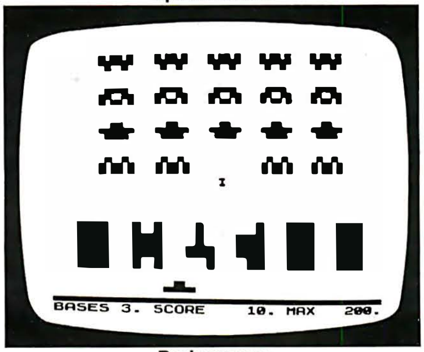
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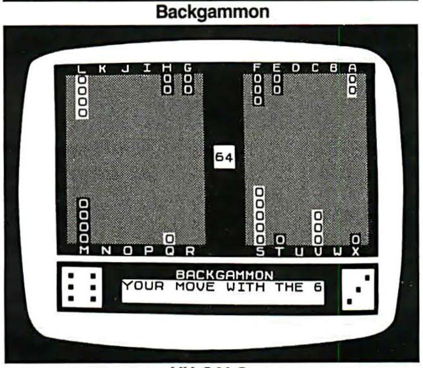
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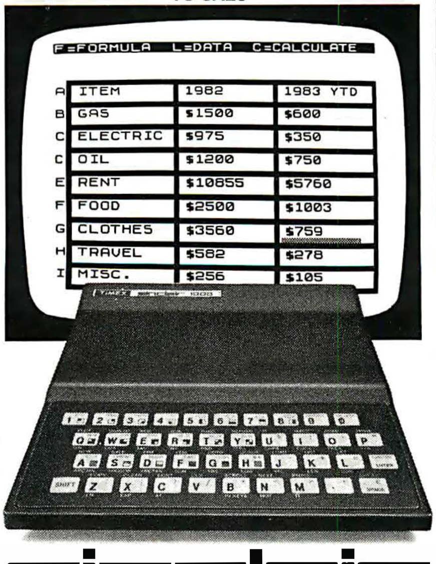
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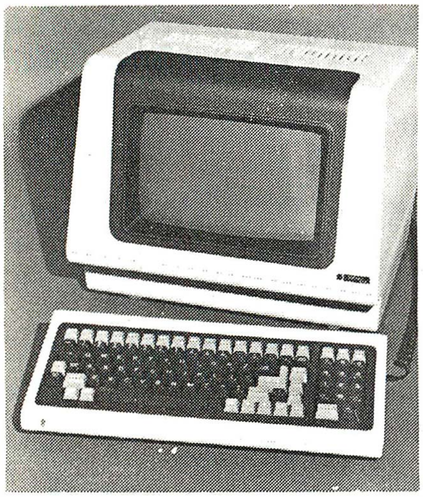
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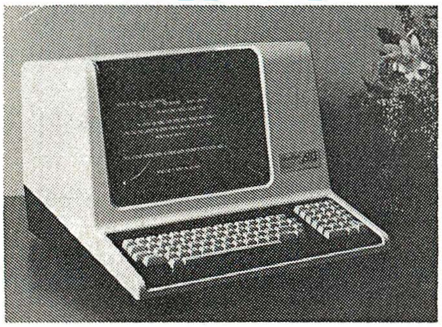


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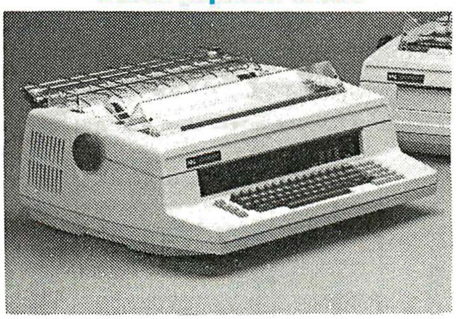
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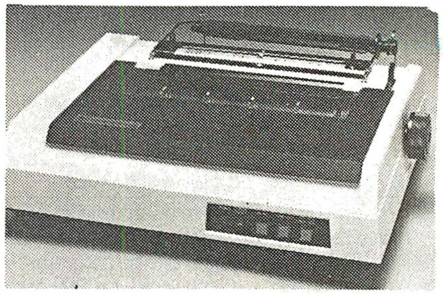
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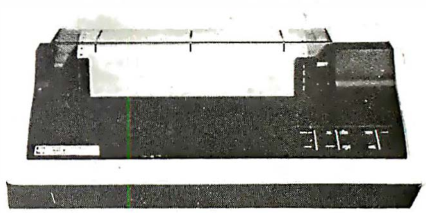
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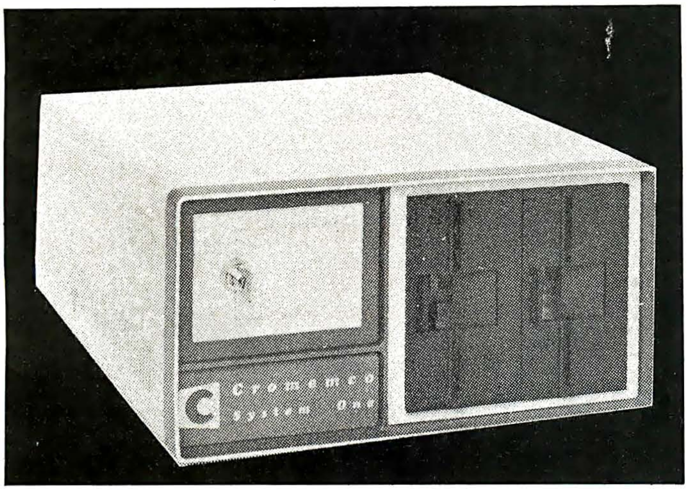
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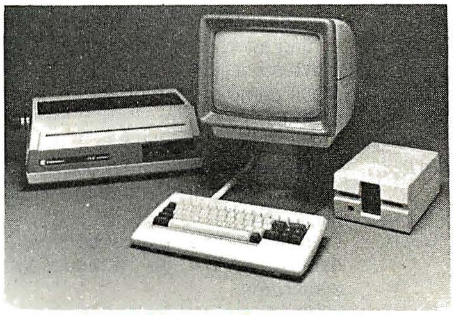
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Exploring the Commodore VIC-20

Joel Swank
12550 SW Colony #3
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I was excited when I first obtained my Commodore VIC-20, and I spent several contented days playing with the new system. I soon realized, though, that it was capable of much more than simple games, so I decided to explore further. The nontechnical users manual offered little help; I would have to do my exploring on my own. Moreover, because the VIC has only CBM BASIC, determining its internal workings would be difficult.

The first step in unraveling the mysteries of the VIC is to find the location of the system functions (memory, input/output ports, and programs) in the memory space of its 6502 microprocessor. All documentation for the 6502 processor uses hexadecimal numbers to describe its features, but the VIC's BASIC uses decimal numbers only. Working with the 6502 requires using hexadecimal numbers. To solve this problem I wrote the VIC Memory Utility Program, a BASIC program that emulates a few of the capabilities of a monitor program (see listing 1). It has seven functions executed by typing RUN1, RUN2, RUN3, etc. (see table 1). The utility program allows you to display memory in hexadecimal and ASCII (American Standard Code for Information Interchange), alter memory in hexadecimal, convert hexadecimal to decimal and decimal to hexadecimal, convert hexadecimal to binary, and execute a machine-language program. The base conversion of numbers can be of great help to those unfamiliar with hexadecimal and binary notations. Using the utility program, I was able to learn a great deal about the VIC's functions.

RUN1	Hexadecimal dump of memory. Enter the starting and ending addresses when prompted. Memory is dumped 4 bytes per line.
RUN2	ASCII dump of memory. Enter the starting and ending addresses when prompted. Memory is displayed in ASCII, 8 bytes per line.
RUN3	Hexadecimal to decimal conversion. Enter the hexadecimal number; the decimal equivalent will be displayed.
RUN4	Decimal to hexadecimal conversion. Enter the decimal number; the hexadecimal equivalent will be displayed.
RUN5	Hexadecimal to binary conversion. Enter a hexadecimal number up to four digits long; the binary equivalent will be displayed.
RUN6	Jump to machine-language program. Enter the address of the program in hexadecimal. The SYS command is used to execute the program.
RUN7	Hexadecimal POKE. Enter the starting address in hexadecimal and then each byte in hexadecimal after its address is displayed. Type END to stop.

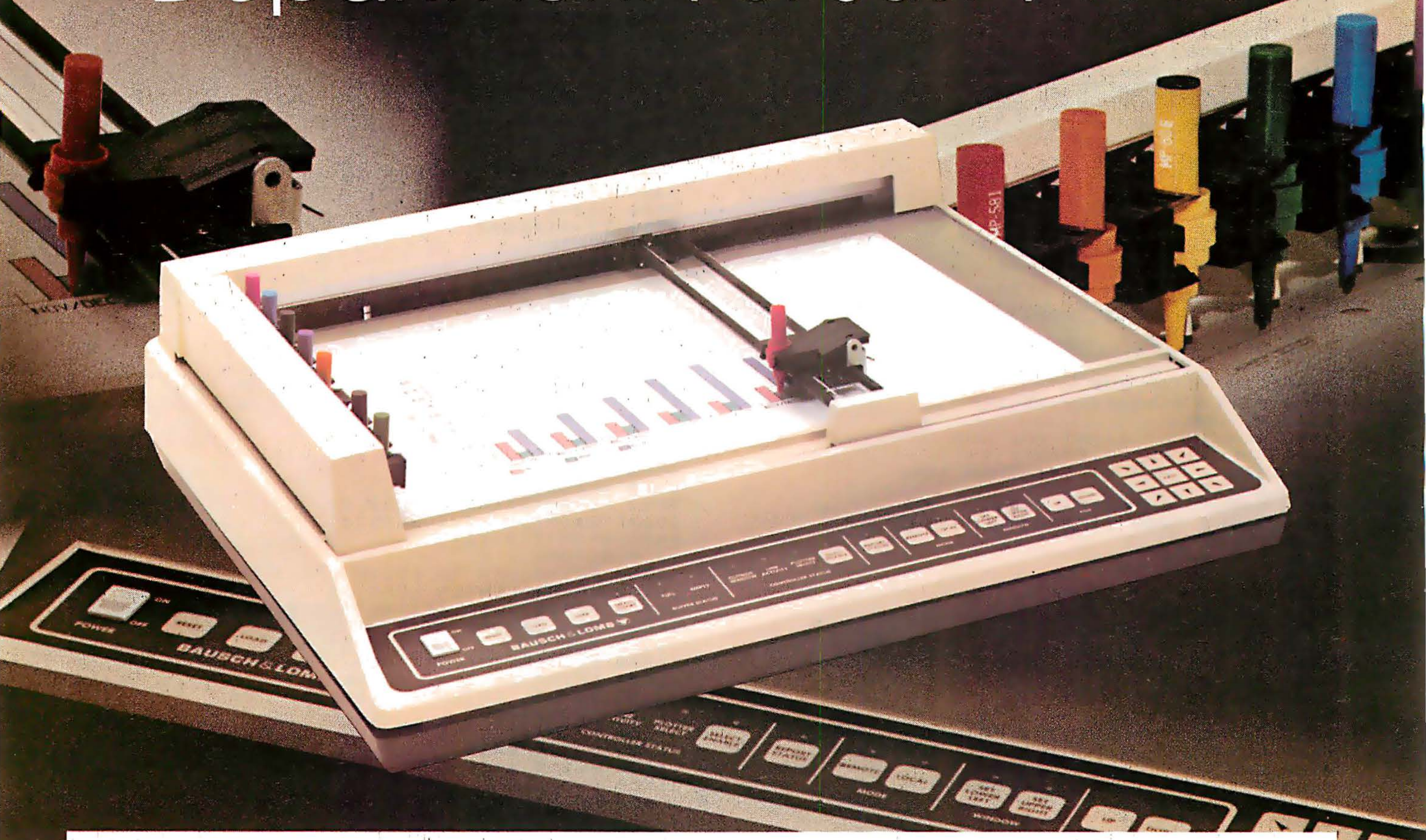
Table 1: *Memory Utility Program functions. When you enter the commands RUN1, RUN2, etc., the program will perform the corresponding functions.*

Memory Locations

Some of the locations of the VIC's functions are given in the users manual in decimal numbers. Using these as a start, I soon had mapped the entire 64K-byte memory space (see figure 1). The lower half of the address space is reserved for RAM (random-access read/write memory), while the upper half is for ROM (read-only memory) and I/O (input/output). The control program for the VIC is stored in ROM, and BASIC programs are stored in RAM. Some of the things that I found while exploring the VIC are described in the following paragraphs. All addresses are given in both hexadecimal and decimal. Hexadecimal numbers are preceded by a dollar sign ($); decimal numbers are in parentheses.

The patterns for the VIC's character sets are contained

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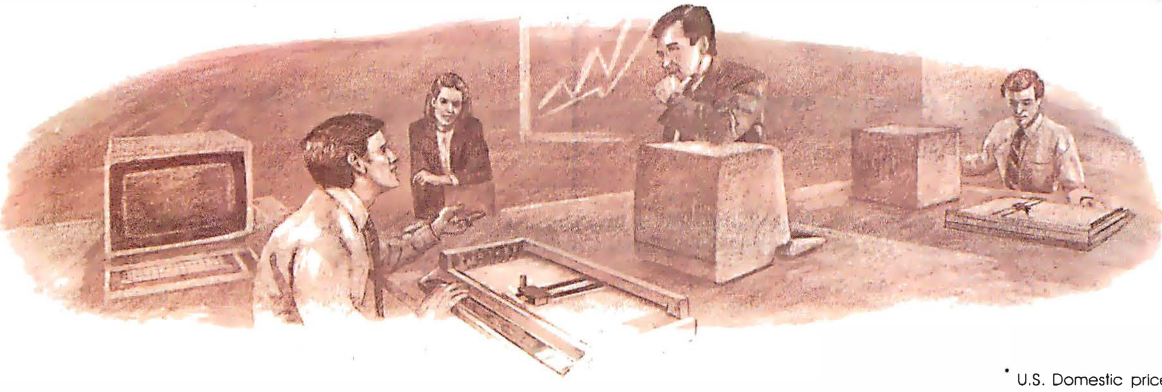
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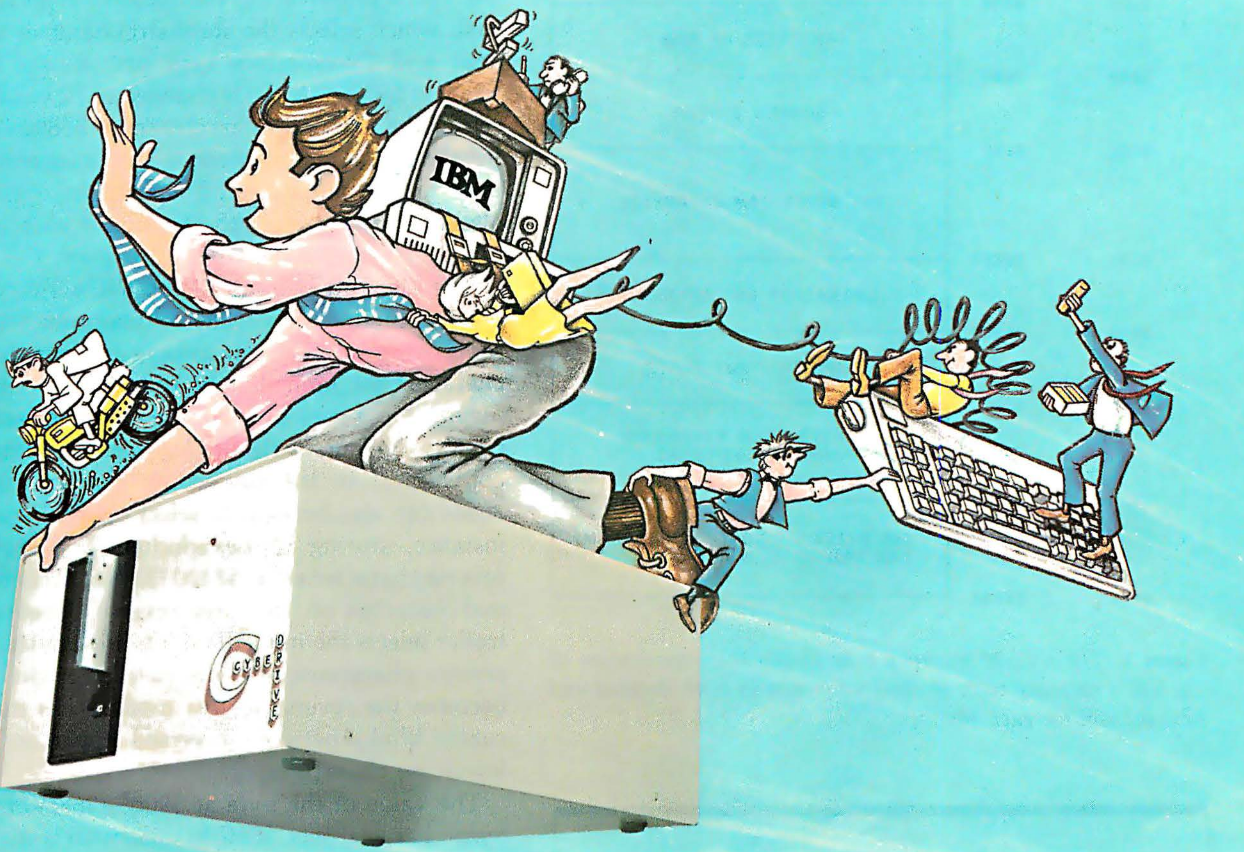
Circle 50 to have representative call.

Listing 1: *Memory Utility Program. This operates much like a monitor program, enabling you to examine and modify the VIC-20's memory.*

```
 READY.

0 REM VIC MEMORY UTILITY
1 GOTO100     :HEX DUMP
2 GOTO4000    :ASCII DUMP
3 GOTO10000   :HEX TO DECIMAL
4 GOTO11000   :DECIMAL TO HEX
5 GOTO6000    :HEX TO BINARY
6 GOTO5000    :JUMP TO SUBROUTINE
7 GOTO12000   :HEX POKE
10 REM
100 PRINT"HEX DUMP"
150 GOSUB2000
200 GOSUB 3000
300 J=1
400 FOR I=SSTOEN
450 IFJ=1THENGOSUB8000
500 X%=PEEK(I)
600 GOSUB 9600
1000 PRINT" ";
1100 J=J+1:IF J<5 THEN1300
1200 PRINT:J=1
1300 NEXT
1400 END
1900 REM SETUP SUB
2000 HEX$="0123456789ABCDEF"
2100 RETURN
2990 REM INPUT START AND END
3000 INPUT "ENTER START";S$
3220 GOSUB 7000 :IFTT<0THEN 3000
3230 SS=TT
3300 INPUT "ENTER END";S$
3320 GOSUB 7000 :IFTT<0THEN3300
3330 EN=TT
3500 RETURN
3990 REM
4000 PRINT"ASCII DUMP"
4030 GOSUB 3000
4050 J=1:GOSUB 2000
4100 FOR I=SS TO EN
4150 IF J=1THENGOSUB 8000
4200 X=PEEK(I)
4300 IFX>191THENX=32
4400 PRINTCHR$(X);
4500 J=J+1:IFJ=9THENJ=1:PRINT
4600 NEXT
4700 END
5000 PRINT"JUMP TO ML PROGRAM"
5100 GOSUB2000
5200 INPUT"ENTER 'TO' ADDRESS";S$
5300 GOSUB 7000:IFTT<0 THEN GOTO5200
5400 SYS(TT)
5500 END
5900 REM
6000 PRINT"HEX TO BINARY"
6100 INPUT "ENTER HEX";S$
6200 IF LEN(S$)>4 THENGOSUB 7750:GOTO6100
6300 GOSUB 7000:IFTT<0THEN6100
6400 M=2↑15:J=0
6500 FOR I=1TO16
6600 J=J+1:IFJ=5THENJ=1:PRINT" ";
6700 IF TT-M>=0THENPRINT"1";:TT=TT-M:GOTO6900
6800 PRINT"0";
6900 M=M/2:NEXT:END
7000 REM CONVERT HEX TO DECIMAL SUB
7050 TT=0:FOR L=1TO LEN(S$)
7100 T$=MID$(S$,L,1)
7150 IFT$<"0"THEN 7700
7200 IFT$>"9"THEN7350
7250 J=VAL(T$)
7300 GOTO 7550
7350 FORJ=1TO6
7400 IFT$=MID$("ABCDEF",J,1)THEN7500
7450 NEXTJ:GOTO7700
7500 J=J+9
7550 TT=TT*16+J
7600 NEXTL
7650 RETURN
7700 TT=-1
7750 PRINT"INVALID HEX #"
7800 RETURN
7900 REM PRINT I AS 4 HEX DIGITS
8000 X%=INT(I/256)
8100 GOSUB 9600
8200 X%=INT(I-INT(I/256)*256)
8300 GOSUB 9600
8400 PRINT" ";
8500 RETURN
9500 REM PRINT X% AS 2 HEX DIGITS
9600 Y%=INT(X%/16)
9700 Z%=X%-Y%*16
9800 T1$=MID$(HEX$,Y%+1,1)
9900 T2$=MID$(HEX$,Z%+1,1)
9950 PRINTT1$;T2$;
9960 RETURN
10000 PRINT"HEX TO DECIMAL"
10100 INPUT "ENTER HEX";S$
10200 GOSUB 7000:IFTT<0THEN10100
10300 PRINTS$;"=";TT
10400 END
10900 REM DECIMAL TO HEX
11000 PRINT"DECIMAL TO HEX"
11100 INPUT "ENTER DECIMAL";I
11150 GOSUB2000
11200 PRINTI;"=";
11300 GOSUB2000
11400 GOSUB 8000
11500 END
12000 PRINT"HEX POKE"
12100 GOSUB2000
12200 INPUT"ENTER START ADDRESS";S$
12300 GOSUB7000:IFTT<0THEN12200
12400 ADD=TT
12500 I=ADD:GOSUB8000:INPUTS$
12600 IFS$="END"THEN END
12700 GOSUB7000: IF TT<0THEN12500
12750 IFTT>255THENGOSUB7750:GOTO12500
12800 POKEADD,TT
12900 ADD=ADD+1:GOTO12500
 READY.
```

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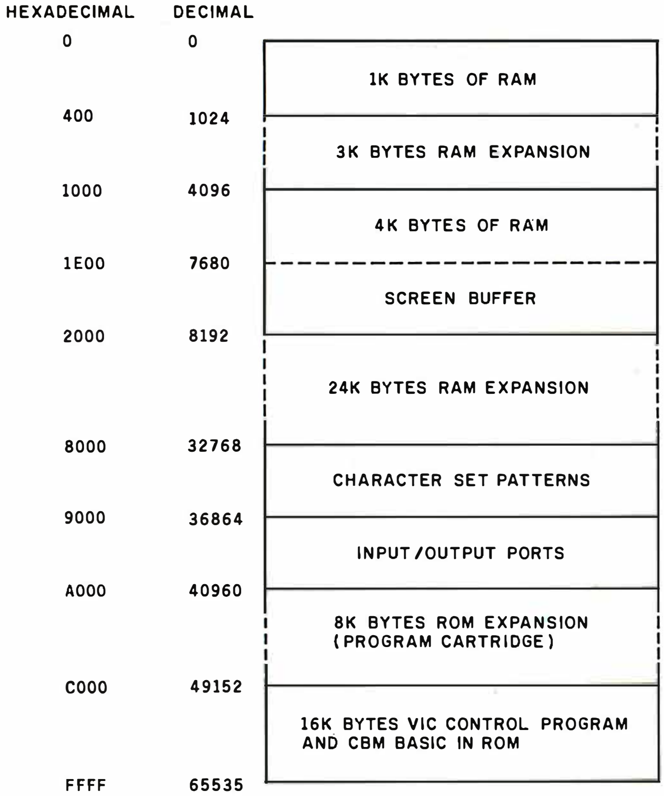


Figure 1: *The VIC-20 memory map shows the organization of the VIC's memory with starting addresses in both decimal and hexadecimal for each block.*

\$9000–\$900F	(36864–36879)	TV controller
\$9000	(36864)	Horizontal position control
\$9001	(36865)	Vertical position control
\$9005	(36869)	Character set selection
\$900A–\$900E	(36874–36878)	Sound control
\$900F	(36879)	Screen/border color control
\$9110–\$911F	(37136–37151)	First 6522 VIA; controls user port, joysticks, and light pen
\$9120–\$912F	(37152–37167)	Second 6522 VIA; controls keyboard, printer, disk, and tape

Table 2: *Input and output addresses. The values at these memory locations control the video and sound output as well as the input and output from the keyboard and peripherals.*

in a 4K-byte ROM located at \$8000 (32768). The pattern for each character requires 8 bytes of data. The bits of the first byte determine which dots of the top row of the character will be on, the second byte does the same for the second row, and so on. The order of the character patterns in the ROM is the same as the order in the table on page 141 of the users manual. There are actually four separate character sets contained in this ROM, each taking 1K bytes for the patterns of the 128 characters per set. The first set, located at \$8000 (32768), is the standard VIC character set. The next, at \$8400 (33792), is the reverse standard character set. At \$8800 (34816) is the VIC alternate character set that includes lowercase letters in place of graphics. At \$8C00 (35840) is the reverse of the alternate character set. The byte at \$9005 (36869) determines which of these character sets is used. When the VIC is powered on, this location is set to F0 hexadecimal, which selects the standard character set. When the shift and Commodore keys are pressed together, the value in \$9005 (36869) is changed to F2 hexadecimal. This selects the alternate character set at \$8800 (34816). Pressing the shift and Commodore keys a second time changes back to the standard set. The value in location 36869 can also be changed from the keyboard with a POKE command or even from a BASIC program.

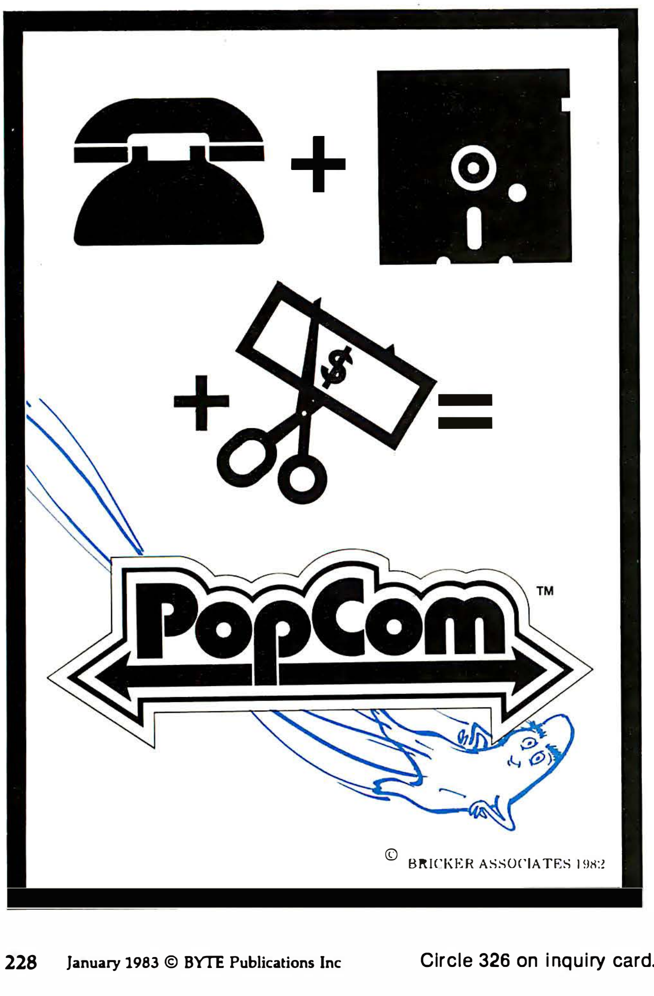
The integrated circuit of the VIC's TV controller uses the value in location 36869 to determine which character set is currently in use. It always assumes that the reverse character set immediately follows the selected one in memory and uses that reverse character set to blink the cursor. The cursor flashes between the character and its counterpart in the succeeding character set. Location 36869 can also be used to select other character sets. For instance, storing F1 hexadecimal in 36869 selects the reverse character set at \$8400 (33792). This makes all normal characters on the screen reverse. Because the TV controller selects the immediately following character set for reverse characters, the alternate character set at \$8800 becomes the reverse in this mode. That means that the cursor blinks between reversed uppercase and normal lowercase characters.

The value of the byte at \$9005 (36869) can select still more character sets. If FC hexadecimal is stored there, the RAM starting at \$1000 (4096) is used for the character patterns. This allows you to design your own character sets. Character sets at \$1400 (5120), \$1800 (6144), and \$1C00 (7168) can also be selected with values FD, FE, and FF hexadecimal respectively. In fact, the 4K-byte block of RAM at \$1000 (4096) will completely replace the ROM at \$8000 (32768), and all features mentioned above will work for the user-designed character sets. Of course, on the standard VIC this RAM area is used for the BASIC program buffer and therefore cannot be used entirely for your own character sets. Also, the screen buffer takes the top 512 bytes of this area.

Input/Output

The entire area from \$9000 (36864) to \$9FFF (40959) is reserved for I/O (see table 2). Locations \$9000 (36864) to \$900F (36879) are for the TV controller. The character sets, screen and border color selections, and sound controls are all located here. Locations \$9000 (36864) and \$9001 (36865) control the horizontal and vertical position of the VIC's screen within the border. I sometimes use my VIC with an ancient black-and-white television. Because the corners of the screen are rounded on this set, each corner of the VIC's display loses three characters off the edge of the screen. To circumvent this, I store an 8 (instead of the normal 5) in location \$9000 (36864). This





$14	(20)	Pointer for POKE and SYS commands
$2B,$2C	(43,44)	Address of start of BASIC memory
$2D,$2E	(45,46)	Address of start of BASIC variables
$2F,$30	(47,48)	Address of start of BASIC arrays
$31,$32	(49,50)	Address of end of BASIC arrays
$33,$34	(51,52)	Address of bottom of BASIC strings
$37,$38	(55,56)	Address of end of BASIC memory
$73	(115)	Subroutine to load next BASIC text character
$A0–$A2	(160–162)	Time of day clock in 60ths of a second since midnight
$AE,$AF	(174,175)	Data pointer for SAVE and LOAD
$B2,$B3	(178,179)	Tape buffer pointer
$B7	(183)	Length of file name for SAVE, LOAD, and OPEN
$BA	(186)	Device code
$BB,$BC	(187,188)	File name pointer for SAVE, LOAD, and OPEN
$C5	(197)	Current key down (if any)
$C6	(198)	Key-input stack pointer
$D1,$D2	(209,210)	Current cursor position in screen buffer
$F3,$F4	(243,244)	Current cursor position in color buffer

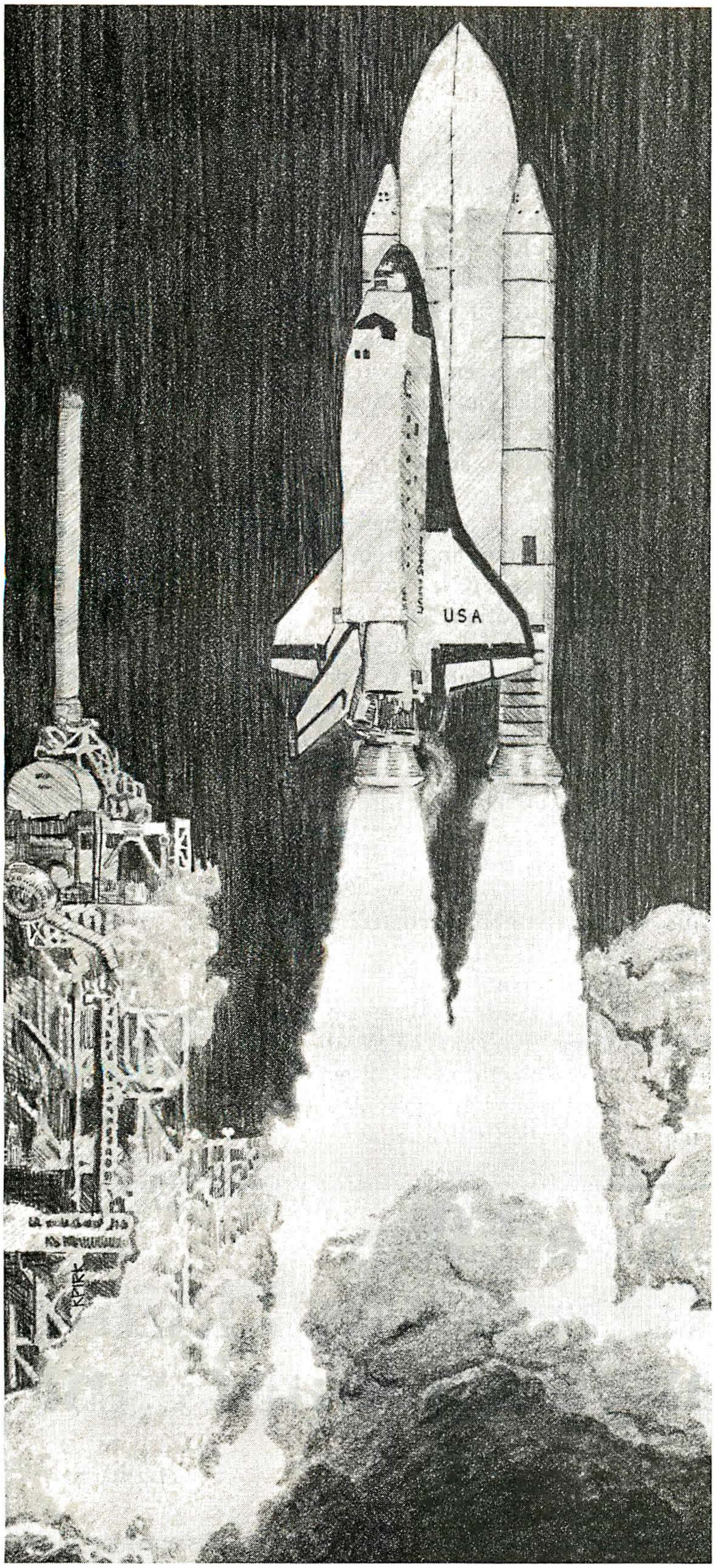
Table 3: *Page 0 memory locations. These addresses show the locations of the various functions of the VIC's operating system.*

$200–$258	(512–600)	Line input buffer
$277–$27F	(631–639)	Key-input stack
$286	(646)	Current color
$28D	(653)	Shift-key-down flag (if any)
$300–$332	(768–818)	User exit vectors
$30C–$30F	(780–783)	Processor register save area for SYS
$33C–$3FB	(828–1019)	Tape buffer

Table 4: *Page 2 and 3 memory locations. The VIC uses these addresses as a scratch-pad memory for the operating system.*

$300	(768)	BASIC error routine
$302	(770)	BASIC warm start
$304	(772)	Keyword-to-token conversion
$306	(774)	LIST command
$314	(788)	IRQ processor interrupt
$316	(790)	BRK processor interrupt
$318	(792)	NMI processor interrupt
$31A	(794)	OPEN command
$31C	(796)	CLOSE command
$324	(804)	Input line from keyboard/screen
$326	(806)	Output a character to screen
$330	(810)	LOAD command
$332	(812)	SAVE command

Table 5: *User exit vectors. You can access particular routines in the VIC's ROM programs by using these addresses.*



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moves the VIC's display to the right, allowing me to see all of the leftmost characters, but more characters are lost off the right side. Because the left side of the screen is used the most, this solution takes care of most situations. I can always use a POKE command to enter a 2 into location 36864 whenever I need to see all of the right side of the display.

Locations $9110 (37136) through $912F (37167) are used to operate the VIC's two 6522 VIAs (versatile interface adapters). These VIAs provide 32 programmable external-control lines that the VIC uses for communication with external devices such as tape, disk, or joysticks.

At location $9400 (37888) are 512 bytes of RAM organized as 1024 half-bytes, or nybbles. A nybble may contain any number between 0 and 15. The nybbles from $9600 (38400) to $97FF (38911) are used for the screen color codes. There is one nybble for each character position in the screen buffer at $1E00 (7680). The color for a character is selected by using a POKE command to enter the color code (0-7) into the desired nybble.

Memory Organization

The RAM on the standard VIC is divided into two sections, the 4K-byte block at $1000 (4096) to $1FFF (8191) and the 1K-byte block at 0 to $3FF (1023). All of the 1K-byte block is reserved for special purposes. Page 0 (0-$FF) is accessed in a special way by the 6502 microprocessor; it contains much of the VIC's most important data. Table 3 lists some of the data that is stored there. Page 1 ($100-$1FF) is reserved by the 6502 for the hardware stack and should not be used by any programs. The VIC uses pages 2 and 3 ($200-$3FF) for various data (see table 4).

One of the VIC's most important features, found at locations $300-$332 (768-818), is the series of user exit vectors. The user vectors are pointers to locations in the VIC's ROM programs. The VIC uses these vectors as the addresses of important routines. This allows you to change the addresses of these routines by changing the addresses in the vectors. The concept of user vectors is common in larger computer systems, but it is just catching on in the microcomputer world. User exits are significant because they make it easy for you or professional software developers to add new features and I/O devices to the VIC, increasing its flexibility (see table 5).

The VIC's design also allows for memory expansion. The logical first step in such expansion is to fit 3K bytes of new RAM into the gap from $400 (1024) to $FFF (4095), between the two blocks of RAM on the standard VIC. This brings the total up to 8K bytes and allows user-designed character sets to be fully implemented. This new RAM also allows the VIC to create high-resolution graphics.

Up to an additional 24K bytes of RAM may be added in the range from $2000 (8192) to $7FFF (32767), giving the VIC a maximum capability of 32K bytes of RAM. Locations $9800 (38912) through $9FFF (40959) are reserved for expansion of the VIC's I/O capability. Any of a wide variety of I/O devices could be added here (up to 2048 of them). Locations $A000 (40960) through $BFFF are reserved for ROM expansion. This is where the VIC's future hardware cartridges will reside. A routine in the VIC's initialization program checks this area for the presence of a cartridge during cold and warm starts. If a cartridge is present, it will be initialized instead of VIC BASIC, thus allowing the program in the cartridge to assume complete control of the VIC.

Conclusion

This article is not meant to be a comprehensive study of the VIC. Nonetheless, the information provided here, together with the VIC Memory Utility Program, should be enough to give you a good start on using your VIC-20 to its fullest potential. ■


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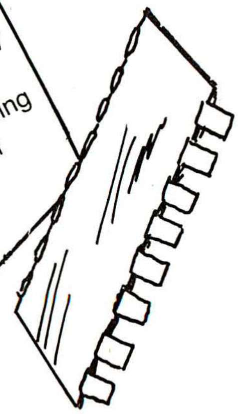
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Atari Player-Missile Graphics in BASIC

The Atari computer offers a unique method to manipulate graphics in a BASIC program.

Paul S. Swanson
97 Jackson St.
Cambridge, MA 02140

If you have ever tried to move an object around on the screen using BASIC, you probably made the object look like it was jumping from one point to the next instead of moving along smoothly. One reason for this is that BASIC, which is an interpretive language, has a major drawback—it is too slow. You may have resorted to a crash course in machine language to find a solution to this problem. But machine language, even with the aid of an assembler to form the code from assembly-language statements, takes longer to program and debug than BASIC.

In addition to being slow, BASIC compounds the problem of moving the object. If it is more than one line high, computations must be made to determine where each line will fall after the move. If the object is 5 dots high and 5 dots wide, you move 25 dots using 5 calculations for determining placement of the object. This does not include the fact that you must first erase the old image, which usually means drawing the shape in the old location using a background color. This doubles the time required from the amount required to draw it—first you "undraw" it in one location, then draw it in the next location.

Consider the possibility of superimposing an object on the screen without disturbing the images already there.

To complicate matters even further, consider the case where you want to move the object "in front" of some other images that you want on the screen. How do you calculate what colors to put back in the place of the old shape? If you don't put them back, the object will leave a path through the images on the screen in the color you are using to erase the object when you move it.

Editor's Note: *This article covers* one *of the methods for working with player-missile graphics. For details on working with* playfield *animation, see "The Atari Tutorial, Part 3: Player-Missile Graphics," BYTE, November 1981, page 312. For an excellent overview of Atari BASIC, see "The Atari Tutorial, Part 6: Atari BASIC," BYTE, February 1982, page 91. . . .***S. J. W.**

The Atari Solution

Consider the possibility of superimposing an object on the screen without disturbing the images already there. The object will not be "on" the screen in memory. Therefore, it will not destroy any part of the images when it moves. Since the Atari computer has two-, four-, and five-color graphics modes, wouldn't it also be nice to use an extra, independent color for this object? That would add a third, fifth, or sixth (depending on the graphics mode) color to the display. As long as we have gone this far, how about having four of these objects, called players, all with independent colors and movements and all with different shapes?

Player-missile graphics on the Atari can do all these things, plus a few other tricks. In addition, it also offers you four 1- or 2-byte-wide "missiles" that you can use.

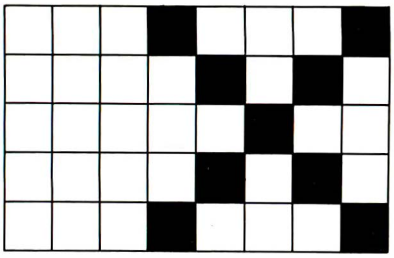


Figure 1: *A 5- by 5-dot X-shape can be defined with only 5 bytes of memory.*

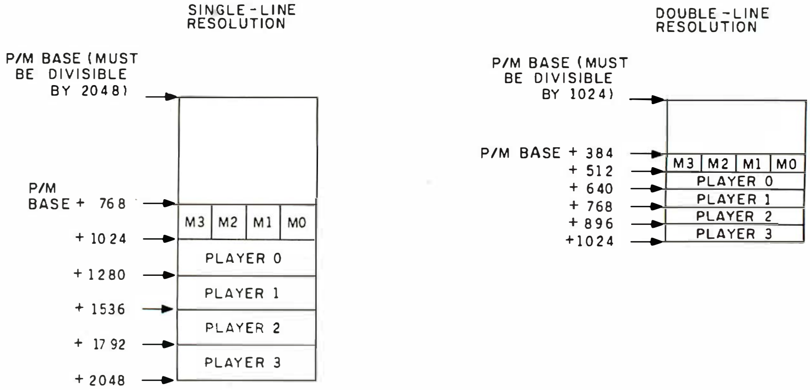


Figure 2: *Memory allocation for the player-missile graphics. Definitions for the shape and vertical position of both the players and missiles are kept in this area of memory.*

The players are 8 dots wide. In addition, the dots for the players and the missiles can be single, double, or quadruple width. The width definition can be controlled for each player, but all missiles must have the same width.

Player-missile graphics also solves another problem. The 5- by 5-dot object that was described earlier will require only 5 bytes to describe its shape and the bytes are next to each other. No separate calculations for each line are required to display the object.

Controlling the players is a fairly simple task. You must describe to the computer the player's position, color, shape, and size. You must also specify what happens if another color is on the screen in the same position as part (or all) of the player. After a few initial steps required to set up the player-missile graphics mode, which is done once for all players and missiles, each of the players is controlled the same way.

Each player occupies a 128-byte strip in memory. A player is one color and is shaped by using one byte in the strip for each horizontal line. Each of the 8 bits will turn on a dot of the player color if it is a 1 and turn off a dot if the bit is a 0. For example, a simple shape such as an X can be defined in a 5- by 5-dot grid (see figure 1), which is what you would do

if you wanted to PLOT the character on the screen.

In figure 1, the values of the 5 bytes required to define it are computed using each horizontal row as 1 byte, taking empty squares as 0 and full squares as 1. The value of the first row converted from binary to decimal is 17, the second row is 10, and the third row is 4. Rows five and six are the same as rows two and one, in that order. The shape may then be defined as a string of characters with the values 17, 10, 4, 10, and 17. (If the figure is not symmetrical, the first byte defines the top of the figure.) Using this method defines the 25-dot figure with only 5 bytes.

Movement

Player-missile graphics uses two different methods to move the player in horizontal and vertical directions. Horizontal motion is the easier. All you do is use the POKE command to enter the horizontal position (0-255) into a memory location. Vertical motion is a little harder. You must move the player up and down in the 128-byte strip.

As you may have suspected, there is one catch to using player-missile graphics. The player-missile area must be located in a certain position with respect to a 1K- or 2K-byte boundary. The sample program (see listing 1) uses a double-line resolution player, which requires that the position be aligned with respect to a 1K-byte boundary (see figure 2). A finer method of describing the player shape (single-line resolution) that requires that it be set up starting at a 2K-byte boundary is also available. In that method, the player strips are 256 bytes long.

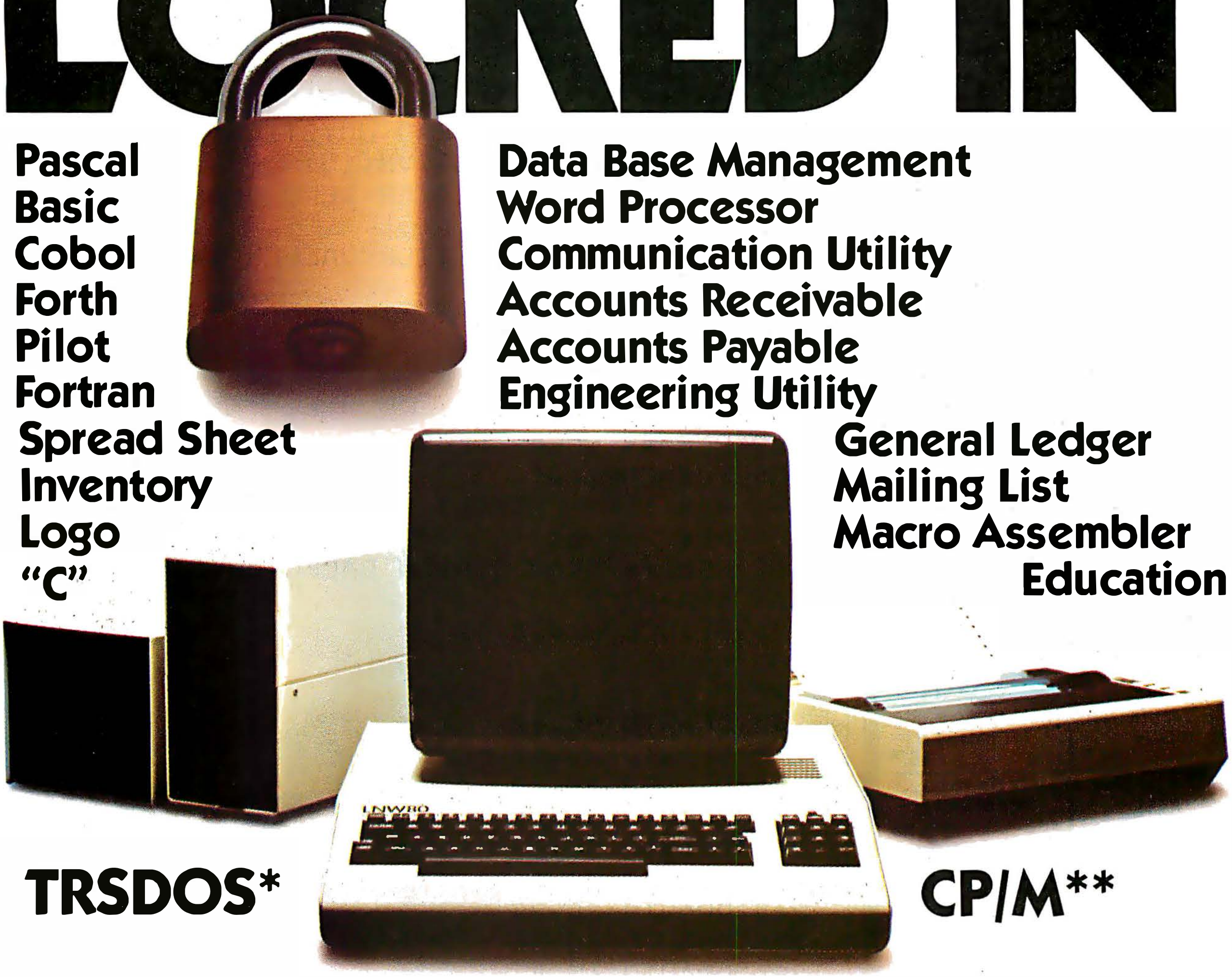
In the double-line resolution method (i.e., each horizontal line of the player is represented by two television scan lines), the missile area must start 384 bytes after a 1K-byte boundary. The missile area is 128 bytes long. After the missile area, at 512 bytes after the 1K-byte boundary, players 0 through 3 take 128 bytes each so that player 3's area ends on the next 1K-byte boundary.

The problem with this is that BASIC locates the string area in memory depending on the length of the program statements as represented in memory. If you modify a program by adding a statement or two, the strings are started in a higher memory location. This makes it difficult to guarantee that a string will start on the 1K-byte boundary.

One solution is to find the area above the memory that BASIC is using and place the player-missile areas there. Then you can use POKE to move the player vertically. This works, but vertical motion is very slow. If the player is moved with a FOR. . .NEXT loop, the vertical motion distorts the shape of the player so that it looks like it is swimming up and down the screen. A loop is too slow. FOR. . .NEXT statements with a POKE in between are not the fastest way to do this.

BASIC can move data around in strings at very high speeds. The POKE command is not too fast because it moves only 1 byte at a

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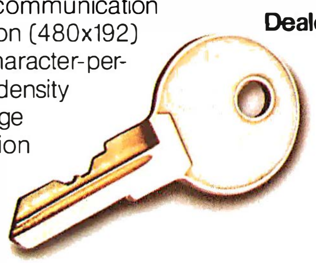
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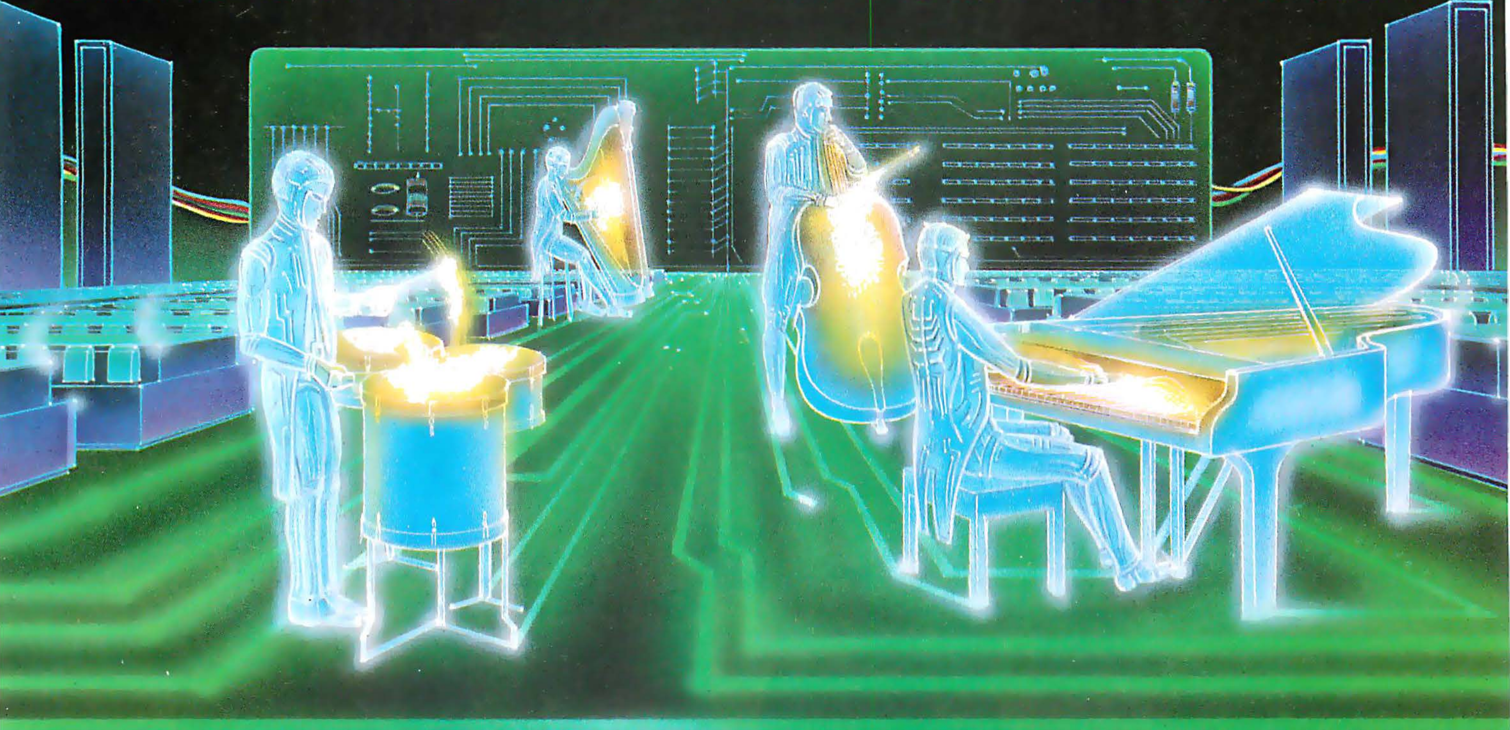
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Listing 1: *Sample program using player-missile graphics. The program requires a joystick.*

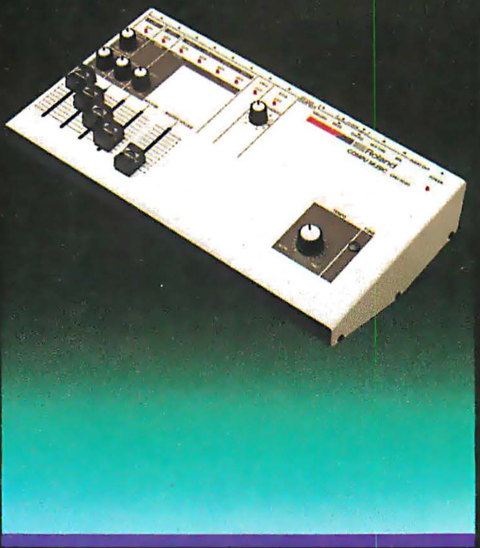
```
  9 REM ** FIND START OF STRING SPACE **
 10 DIM X$(1)
 20 A=ADR(X$)
 29 REM ** GET FIRST 1K BOUNDARY ******
 30 B=INT((A-512)/1024+1)*1024
 39 REM ** FILL UP TO PLAYER 0 AREA ***
 40 DIM F$(B-A+511)
 49 REM ** P0$ IS PLAYER ZERO AREA ****
 50 DIM P0$(128)
 58 REM ** S$ IS SHAPE, HM AND VM ARE
 59 REM ...USED TO READ JOYSTICK ******
 60 DIM S$(12),HM(15),VM(15)
 69 REM ** DEFINE PLAYER ZERO SHAPE ***
 70 S$="A**A"
 79 REM ** READ JOYSTICK VALUES *******
 80 FOR I=1 TO 15
 90 READ HP,VP
 100 HM(I)=HP
 110 VM(I)=VP
 120 NEXT I
 129 REM ** CLEAR PLAYER ZERO AREA ****
 130 P0$=CHR$(0)
 140 P0$(128)=CHR$(0)
 150 P0$(2)=P0$
 159 REM ** DRAW SCREEN BACKGROUND ****
 160 GRAPHICS 4
 170 SETCOLOR 0,0,10
 180 COLOR 1
 190 PLOT 45,18
 200 DRAWTO 45,12
 210 DRAWTO 30,12
 220 DRAWTO 30,24
 230 DRAWTO 55,24
 240 DRAWTO 55,6
 250 DRAWTO 20,6
 260 DRAWTO 20,30
 270 DRAWTO 65,30
 280 DRAWTO 65,0
 290 DRAWTO 20,0
 299 REM ** SET PRIORITY = 1 **********
 300 POKE 623,1
 309 REM ** GIVE ANTIC P/M BASE PAGE **
 310 POKE 54279,INT(B/256)
 319 REM ** SET TWO-LINE GRAPHICS *****
 320 POKE 559,46
 329 REM ** ENABLE P/M GRAPHICS *******
 330 POKE 53277,3
 339 REM ** COLOR = 2, LUM. = 4 *******
 340 POKE 704,36
 349 REM ** HORIZ. POSITION = 110 *****
 350 HP=110
 359 REM ** VERT. POSITION = 50 *******
```

Listing 1 continued on page 244

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Listing 1 continued:

```
360 VP=50
369 REM ** SET HORIZONTAL POSITION ***
370 POKE 53248,HP
379 REM ** SET DOUBLE SIZE PLAYER ****
380 POKE 53256,1
389 REM ** SET NO.BYTES IN PLAYER ****
390 LS=LEN(S$)
409 REM ** INIT. COLLISION FLAG ******
410 HITC=0
419 REM ** DISABLE CURSOR ************
420 POKE 752,1
429 REM ** CLEAR COLLISION REGISTER **
430 POKE 53278,0
439 REM ** PUT PLAYER IN AREA ********
440 P0$(VP,VP+LS)=S$
449 REM ** WAIT UNTIL USER IS READY **
450 ? "PRESS TRIGGER TO START"
460 IF STRIG(0)=1 THEN 460
470 ? "}":REM --CLEAR SCREEN
489 REM ** INITIALIZE SCORE COUNTER **
490 COUNT=0
499 REM ** PLAYER MOVE LOOP **********
500 P0$(VP,VP+LS)=S$
510 COUNT=COUNT+0.1
512 IF COUNT=INT(COUNT) THEN SOUND 1,20,12,7
520 HIT=PEEK(53252)
522 SOUND 1,0,0,0
530 S=STICK(0)
540 HP=HP+HM(S)
550 VP=VP+VM(S)
560 POKE 53248,HP
570 POKE 53278,0
575 IF HP<80 THEN 700
580 ? INT(COUNT);""
590 IF HIT=0 THEN HITC=0:GOTO 500
600 IF HITC=1 THEN 500
610 SOUND 0,20,12,7
620 ? :? "YOU HIT THE WALL!!"
630 ? "THAT COSTS YOU 25 POINTS!!":?
635 COUNT=COUNT+25
640 ? INT(COUNT);"":REM MOVE CURSOR UP
650 SOUND 0,0,0,0
660 HITC=1
670 GOTO 500
699 REM ** END OF GAME ROUTINE **
700 POKE 752,0
710 ? "}":REM CLEAR SCREEN
720 ? "YOUR SCORE : ";COUNT
730 ? "PRESS RETURN TO PLAY AGAIN";
740 INPUT X$
750 GOTO 130
999 REM ** DATA FOR HMOVE,VMOVE ******
1000 DATA 0,0,0,0,0,0,0,0,1,1,1,-1,1,0,0,0,
     -1,1,-1,-1,-1,0,0,0,0,1,0,-1,0,0
```

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time. First, BASIC must read the command and interpret what to do. After all that "overhead," all you get is 1 byte transferred. Using LET statements between strings is a much more efficient method because you have the overhead of reading and interpreting only once. Then the statement can be one that moves as many bytes as you want. It is therefore very much to your advantage to use strings instead of POKE in player-missile graphics.

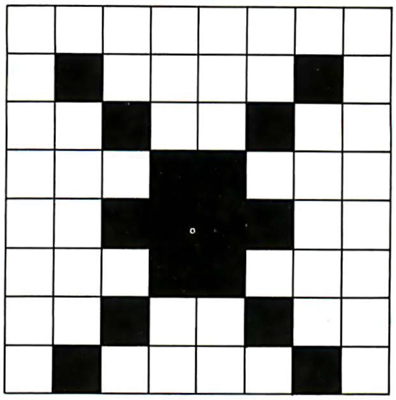


Figure 3: *The modified X-shape as used in the program.*

Sample Game

Listing 1 is included here to help describe how to implement player-missile graphics in BASIC using strings. It is a simple game using a background screen over which player 0 can move. It uses the joystick to get the player out of a simple maze.

Lines 10 through 50 set up and dimension P0$ for player 0, so that the starting location of the string is 512 bytes above a 1K-byte boundary. Lines 10 and 20 find where the string area starts. Line 30 sets B equal to the value of the 1K-byte boundary that is within 512 bytes of the start of the string space. Player 0's area must begin 511 bytes above that location minus A. That is handled by placing a filler string (line 40) to move the pointer that will locate P0$ at the right spot. Line 50 dimensions P0$.

This method will always place P0$ at 512 bytes above a 1K-byte boundary, no matter how long the program is, until you run out of memory. To use players 1 through 3, you can simply add the strings P1$, P2$, and P3$, each dimensioned to 128, onto the dimension statement (keep them in order).

Now that the string has been set in the correct position, initialization of all the variables and other items can take place. The first part defines the player shape. The player in this game is a flattened X. The design is in figure 3. Two zero bytes are used, one on each end of the player (vertically) so that it will erase the old image when you create the new image (the program allows the player to move only one vertical position at a time). The bytes from top to bottom are 0, 65, 42, 28, 28, 42, 65, and 0. Line 70 defines the player using a control-comma for the zero bytes, capital A for 65, an asterisk for 42, and escape-control-hyphen for 28. The characters to use for most values can be found in Appendix C of the *Atari BASIC Reference Manual.* If you are not that ambitious, you can substitute a FOR. . .NEXT loop. The following loop will work in place of line 70:

```
70  FOR I=1 TO 8
72  READ S
74  S$(I)=CHR$(S)
76  NEXT I
78  DATA 0,65,42,28,28,42,65,0
```

The DATA statement in line 78 will not interfere with the operation of the next FOR. . .NEXT loop because the data for that will begin at line 1000.

The loop starting at line 80 reads values into two arrays that will help decode the joystick movements into +1, 0, or −1 horizontally and vertically. The two arrays defined here will make the reading of the joystick much faster; speed is important in that loop.

The next series of statements, starting at line 130, sets all bytes in P0$ to 0. The only bits we want set are where the player is to be. All the others must be 0.

Lines 160 through 290 draw the maze the player is to move through. This maze is actually a spiral-like series of lines at right angles, as you will see when you run the program. Any shape that the player can fit through will work.

The next section of the program, starting at line 300, sets up the player-missile area. One part writes to special memory locations, called hardware registers. These are actually data lines to the graphics controller microprocessor, called ANTIC. It controls the screen display and all graphics commands go through it. ANTIC also superimposes the players and missiles over the screen image.

You can't read what is in the hardware registers, but you can read and write to the shadow registers. The shadow registers are memory locations, which in this case are below 1024. The operating system reads the shadow registers and sends their values to the corresponding hardware registers. These values are sent when the screen is blanked-out before the scanner starts to trace the next video frame. Since ANTIC receives these values 60 times per second, the delay is minimal.

Line 300 refers to one of these shadow registers. This sets up the priority of the players and missiles. Using the POKE command to enter a 1 in this location causes the players and missiles to have priority, which makes them look as if they are moving in front of the images on the screen. A value of 8 causes the players and missiles to appear to move behind the screen image.

Line 310 tells ANTIC (directly—no shadow register) where to find the player-missiles. The value put in this location using POKE is the page number of the 1K-byte boundary that is just below the player-missile area. It adds to this location (INT(B/256)) to find your images.

Line 320 tells ANTIC through a shadow register that you want double-line resolution on the players. Other "legal" codes are at this location that will do different things. Be very careful what you put here with POKE.

The color of player 0 is set at line 340. The value is the color number times 16 plus the luminance value. This location, which is a shadow register, controls the color of player 0 and missile 0 (the missiles are the same color as the player of the same number). You can set the colors for

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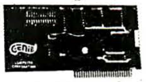


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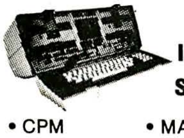


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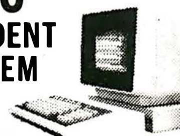
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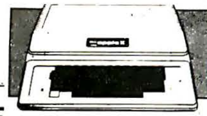
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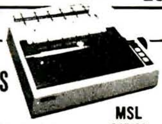
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players 1, 2, and 3 by adding lines to POKE values in registers 705, 706, and 707.

Lines 350 and 360 set the variables that will be used by the program for the horizontal and vertical position values of the player. Line 370 tells ANTIC what the horizontal position of player 0 is to be. Players 1, 2, and 3 are in locations 53249, 53250, and 53251. The horizontal positions for missiles 0 through 3 are at locations 53252 through 53255.

Line 380 sets ANTIC to display the shape at double its horizontal size. Values of 0 and 2 at this location set single size; a value of 3 sets quadruple size. This is read in binary and the last 2 bits are the only ones that are read by ANTIC. Therefore, a value of 4 will be interpreted as a 0, a 5 as a 1, etc. Players 1, 2, and 3 use locations 53257, 53258, and 53259.

LS is set to the length of S$ in line 390. The variable LS is used in moving the player instead of LEN(S$) because it is faster.

There is a provision for reading when players are in "conflict" with other players, screen colors, and missiles. Also, another provision detects a conflict between missiles and screen colors. Separate locations can be read to find out if such a conflict has occurred, one of which is used in this program. HITC is used in the program (line 410) to store a flag of 1 if a conflict has taken place and has not been cleared.

A constantly updated display will be in the text window that shows elapsed time. Because the cursor would serve no purpose in it and would make the number harder to read, line 420 shuts it off.

When a conflict has taken place, the corresponding location is set to 1. It is not reset when the player or missile is moved out of conflict. Location 53278 resets all the conflict indicators (Atari uses the term "collision" instead of conflict). ANTIC sets the registers again a few milliseconds later if there is still a conflict.

Line 440 places the player on the screen by putting the shape into the player area. This string statement can now be used because the player-area string is in the correct position. This

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Line Number	Description
500	Places the player image into the player area at vertical location VP. The first time through this has already been done, but the loop must always end by repositioning the player. It branches back to 500 to do this.
510	Increments the counter by 0.1. This is incremented each time the loop is run and will have the effect of timing the game in arbitrary units.
512	At each tenth increment, when COUNT is an integer, the computer will generate a click in the television speaker. The person playing can keep track of time without referring to a number that he or she hasn't got time to look at.
520	Reads the collision register for player-to-playfield position.
522	Shuts off the sound started in line 512.
530	Reads the value of joystick 0.
540-550	Updates the horizontal and vertical positions using the two arrays to interpret the joystick value returned.
560	Tells ANTIC what the new horizontal position is.
570	Clears the collision registers. ANTIC has plenty of time between this statement and the next read of the collision register (line 520) to update them several times.
575	Detects the end of the game.
580	Displays the current time value.
590	Clears the HITC flag and returns to the beginning of the loop if there is no conflict.
600	Begins the routine that is used when the player hits the side of the maze. If the HITC flag is 1, the hit was already counted. Therefore, this statement goes back to the beginning.
610	Begins sound effect of hitting the wall.
620-640	Displays message that the player hit the wall, adds a penalty to the timer, and redisplays the timer.
650	Stops sound effect started at line 610.
660	Sets HITC flag to indicate hit has been counted.
670	Goes back to start next loop.
700	Line 575 branches here if the player is moved beyond the left edge of the maze, which is assumed to end the game. Since a message will be printed followed by an INPUT statement, line 700 turns the cursor back on.
710-740	Displays the full score (previous displays were the integer value) and waits for the RETURN key.
750	Goes back for another game.

Table 1: *Description of the main section of the sample program. Lines previous to line 500 initialized the player-missile graphics.*

statement replaces, in this example, 8 POKE statements, which would take much longer to execute. The statement in line 440, placed in a FOR. . .NEXT loop that goes from 1 to 1000, takes 15 seconds. Using a corresponding POKE statement in a FOR. . .NEXT loop to place 8 bytes would have taken 2 minutes, 38 seconds in the same FOR. . .NEXT loop. Allowing 8.5 seconds for the FOR. . .NEXT loop, a simple division shows that line 440 is more than 17 times faster than using a POKE statement.

Lines 450 through 490 first wait for the person playing the game to press the trigger button and then set the scoring variable COUNT to 0. Note that the clear screen statements clear only the text window.

Now that everything is initialized, we can use player-missile graphics in the game. Because of the concern for speed of execution, REM statements were minimized in the next portion of the program. The function of these statements is described in table 1.

The program cannot check to see if you go "through" a wall when you hit it—it merely fines you 25 points.

Error Checking

This game does have a few faults (meaning that it is not idiot-proof). It has no checks if the player is moved off the screen and out of the player area. This will result in error messages. The program cannot check to see if you go "through" a wall when you hit it. It will fine you 25 points when you hit the wall, but has no way of determining if you got out of the conflict on the correct side of the wall. Lastly, it tests for the "game over" condition by checking the horizontal position of the player. If it is low enough, it is assumed that the player left the maze at the correct point.

The above faults can be eliminated by using extra statements in the loop (lines 500 through 670) to test the conditions. Testing if the player went through a wall instead of going back from where it came may be a little difficult, but the range check is simple—just test that HP is between 0 and 255 and that VP is between 1 and 128-LS. You can refine the finish test by also testing that the vertical position is less than 18 (like the screen vertical positions, the player-missile vertical positions go from the top = 1 to the bottom = 128).

The collision-detection register will not be 1 for a collision if you do not use, in this case, the COLOR 1 statement for the maze. The detection is bit-coded so that it may also tell you what you hit. Because the low-order 4 bits are used, the value never exceeds 15. The positions of the bits that are on correspond to the SETCOLOR numbers of the color bit. The register indicates 1 for color 0, 2 for color 1, 4 for color 2, and 8 for color 3. The BASIC COLOR statement COLOR 1 actually specifies the color from color register 0, which is why it returns a value of 1. If the maze were drawn with a COLOR 2 statement preceding it, the collision detection would return a 2 when there is a conflict. The program would have to be altered to compensate for this.

Note one very important item in the use of strings for the player-missile graphics. The player positions will move when you go from deferred mode while the program is running to immediate mode. This is caused by BASIC moving things around when the program is not running. Any position tests you do on the player must be done during the time the program is running. Stopping the program with the Break key, then using CONT to resume, will also alter the

position. The program should be RUN from the beginning to get an accurate position.

You may also have noticed that, when you go to the second or subsequent game by pressing Return at the end of one game, the player turns into a jittering stripe running vertically the full length of the screen. This happens when a player is on the screen during a GRAPHICS statement execution. This will destroy the position of the player, causing the line of garbage. In this program, the player-missile graphics is reinitialized completely, which puts the player back where it belongs. When writing the initialization part of programs that use player-missile graphics, remember to execute the GRAPHICS statement before you set up the player-missile graphics. The stripe can be eliminated in this program by adding the line

```
745  POKE 53248,0
```

This moves the player off the left side of the screen. The vertical stripe still exists, but it occurs in the part of the video cycle where the scanner is turned off to go from the end of one line to the beginning of the next line.

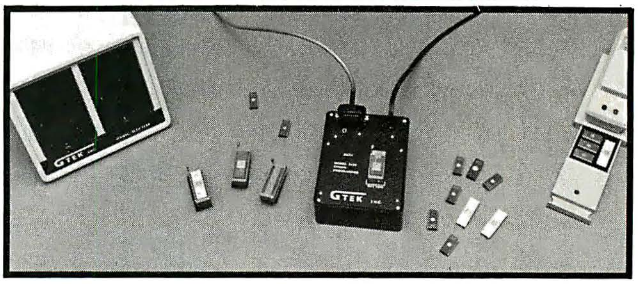
You can also move the player faster by making it increment twice in each loop. The fastest way to do this is to first add zero bytes at the beginning and ending of S$ so that it starts and ends with two zeros instead of one. Second, alter lines 540 and 550 to add HM(S)*2 and VM(S)*2 instead of HM(S) and VM(S). The player will not move quite as smoothly as before, but will still be vastly smoother than if you plotted it directly on the screen.

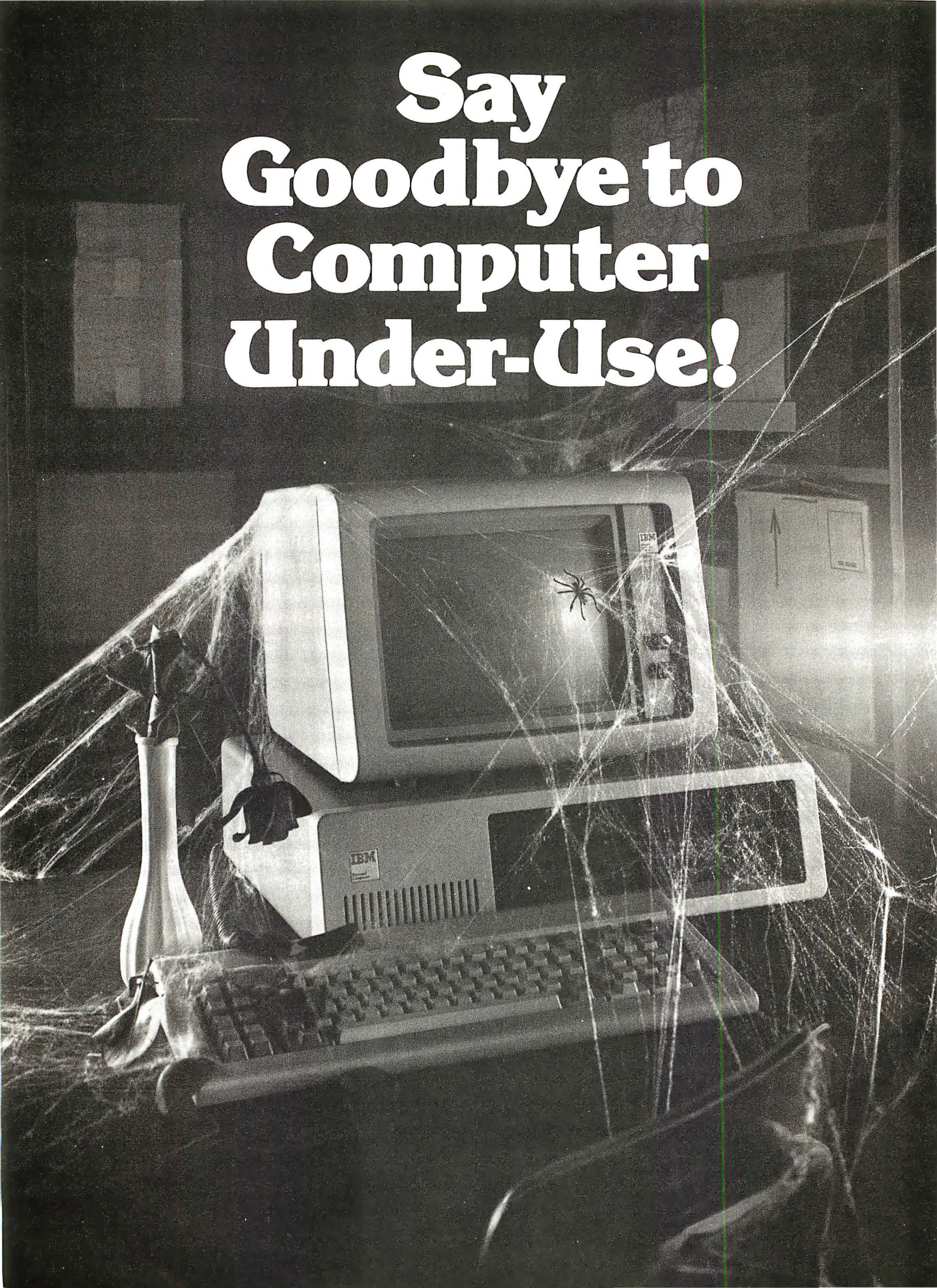
Conclusion

This is only a brief introduction and one example of player-missile graphics. Atari can supply you with manuals that describe them in more detail. You can combine the information from Atari manuals with this method to create some very impressive graphics. The method of locating boundaries for setting the start of arrays can also be used to place alternate character sets for character graphics, screen displays, and display lists.

This method of moving the players in BASIC opens up more uses for BASIC in graphics, but it is still a very slow way to execute graphics routines if they require smooth motions around the screen. It can be used only if the computations and testing required in the loop are small in number. Remember that BASIC is running in milliseconds, not microseconds like machine language; it is 1000 times slower at its best.

The incredible graphics power of your Atari computer can, as shown in this modest example, compensate for the speed difference somewhat and perform some things that are not possible in BASIC on any other microcomputer I have used. If you take advantage of the right things, for example, the speed of string-to-string transfers in LET statements, you will be amazed at what your Atari can do—even in BASIC. ■




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Problem Oriented Language

Part 2: Writing a Module

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In part 1 of this series (December 1982 BYTE, page 314), the concept of a Problem Oriented Language (POL) was introduced. POL uses input that incorporates terms normally used in describing a particular problem. These terms are organized into phrases and sentences that resemble English sentences. The input is relatively free of the format restrictions normally associated with question-and-answer or menu input. Much more information can be input with a single entry. A typical entry, such as, "Draw an XY graph, X from 0 to 4, Y from −2 to 3, Title 'Contour Plot', Execute", would replace dozens of responses required for other types of input. POL-type programs are normally used in technical or graphics applications where there are many possible parameters to change but only a few need to be set at any given time.

The Problem Oriented Language Programming System (POL/PS) was introduced in order to provide microcomputers with the capability of handling POL, especially in terms of solving technical problems. The series of routines (POL-80) for handling POL input was presented and their capabilities were examined.

Developing a Module

One of the goals of POL/PS is to enable the user to write programs in a modular format. Programs can then be easily extended, and the modules can be used in other programs.

POL-80 was developed from my experiences with a FORTRAN system called GRIP. One of the problems encountered in the writing of GRIP-compatible modules (see part 1 for more background on GRIP) is the lack of proper program development. Frequently, GRIP programs have had input that is as awkward as the question-and-answer sessions they were designed to replace. In addition, there has been some resistance to the use of GRIP because of the "difficulty" in understanding what it did and how it could be used. Rick Hilst (current developer of GRIP) and I have discussed at length how to simplify the learning process. Based on classroom experience, we have developed a series of eight steps that can be useful in the writing of most programs, but which *must* be used in writing POL programs. *The steps must be followed faithfully.* Using these steps can cut the learning time in half for POL/PS and can reduce program development time by 25 to 50 percent.

One of the goals of POL/PS is to enable the user to write programs in a modular format.

As a sample problem, we're going to develop a module to find the roots of polynomial equations by using five common methods. (The root of a polynomial equation, such as $P(X)$, is a number A such that $P(A)=0$.) Although this module can be used by itself, it is best used as part of a larger numerical-methods program, or it can be used as a module in other programs. Actually, this module is rather small and its application is somewhat trivial, but it is representative of the much more complex and powerful modules that would be part of an application package. Larger modules may have more statements, but the part of the module relating to the framework of POL/PS would not be any more complicated. Root finding was chosen because the actual computations are relatively simple. Thus, the user may be able to concentrate more on the input and other aspects of POL/PS. Larger, more complex modules will have a greater degree of difficulty in their mathematical computations, but the input should not be any more difficult.

For those not familiar with numerical methods, root finding is done by making an initial estimate of one of the roots of an equation, checking the value obtained, and ad-

justing the estimate according to some formula. This trial-and-error method is continued until the root is found within some acceptable error criteria.

Step by Step

The first step in developing a POL program follows.

1. *Write a paragraph identifying the goals of the program or module.* Be specific! The more careful you are now, the fewer problems there will be later. For the sample module, the goals are these:

> The module will find roots of equations using five methods: Newton's, Approximate Newton's, Secant, Interval-Halving, and Regula Falsi. Failure to find roots will be indicated, if necessary.

This paragraph lists the main result desired and the standard algorithms (plans for step-by-step solutions) that will be used. A secondary goal (an additional or alternate output) is also indicated—a possible alternative to the main result.

2. *Define all the expected forms of output.* Our sample module requires that (A) the numerical value of the root found will be output to the terminal, along with the number of evaluation attempts required, and (B) failure to find a root will be indicated by a message to the terminal listing the number of evaluations attempted.

The specific form of each output is well defined, whereas it was only hinted at in step 1. Frequently, programmers begin to plan the actual code at this point. This is unfortunate because both the output and the *input* must be defined *before* the program design can be done well.

3. *Identify the information required to produce the desired output.* The information inputs required for root finding include:

- the method to be used
- the equation to be solved
- the derivative of *Y* with respect to *X* when Newton's method is used
- initial estimates of the roots
- the maximum number of evaluations permitted before declaring failure
- the absolute value of *Y* that is the criterion for success

Each of these inputs must be changeable because different situations may require different values. It is also desirable to be able to change any of the inputs without leaving the program, especially when changing equations.

At this point, we realize that we need the ability to verify that the starting values required for the regula falsi and interval-halving methods actually trap a root between them. This means that one point gives a positive value for *Y*; the other gives a negative value. In verifying that the two starting points give proper *Y* values, we must *add* an additional output to step 2: (C) output the value of *Y* of the equation for any given *X*.

The inputs identified in step 3 are determined by steps 1 and 2, i.e., they are the ones required to meet the goals of step 1 and produce the output of step 2. Other input should not be required within this module.

4. *Choose the format of the input.* We identified three input formats in part 1: question-and-answer, menu, and POL. POL will be our choice for several reasons: (A) the user of this module is expected to be familiar with numerical methods, and probably will use this module frequently enough to remain familiar with the keywords; (B) usually, several tests or trials will be run at one session with only minor changes in the parameters between trials; and (C) in a large numerical-methods package, the initial keyword can eliminate a question or a menu, and the whole input is much faster and easier.

Not all problems are suited to the POL method, but technical problems, especially those requiring graphics, are easily adapted to this form of input.

5. *Design the input.* Now is the time

to actually choose the keywords used to enter the information. To identify this module, we will use the word "Roots." Command sequences for various types of input are then formed. These sequences should use terms that normally describe the type of problem involved. A sample input for this module might be this:

> Roots using secant, the equation is 'Y=SIN(X)', starting points are 2 and 2.1, execute

Many other possible lines could be shown, but this one will serve as an example.

At this time, the number of characters to be matched within each keyword should be chosen. (I choose four unless I feel that I must have more.) Rewriting the input, capitalizing the required letters of the keywords, results in

> ROOTs USINg SECAnt, the EQUAtion is 'Y=SIN(X)', STARting points are 2 and 2.1, EXECute

Note that some words do not have a portion capitalized. These are "filler" words used to make the input more readable. However, the program must be able to recognize and skip over them. Some common fillers can *always* be omitted. The ones omitted for this module are "A_", "AN_", "THE_", "FOR_", "AND_", "OF_", "EQUAL_", "EQUALS_", "IS_", and "ARE_" (where the underscore represents a space). In addition, two characters will always be skipped—"," and "=". The word "points" in the previous example is skipped on a location-by-location basis.

6. *Write the "tree" structure.* As we write the input lines for the previous section, we should also arrange the keywords in a hierarchical structure. The simplest way to show this structure is a "tree" diagram. Each branch should have only one meaning or function. Sometimes, several branches will use the same words and sections of the program, but internal flags can maintain the difference.

The tree for this module is shown in listing 1. Sufficient keywords and options are available in it to perform all the actions listed under step 3.

7. *Write the "Help" routine.* Now that keywords have been chosen for this problem, we should begin writing the exact functional definitions of each input term and how this term will help attain the desired goals. At this time, the following items should be considered:

- What internal flags will be used to control routines?
- What exact information is required to perform the action associated with each possible input?
- What default values will be used if that information is not supplied?

Listing 1: *Tree structure of keywords for the ROOTs program. The words are arranged in hierarchical order.*

```
ROOTs
        USINg
                NEWTon
                APPRoximate NEWTon
                SECAnt
                INTErval HALving
                REGUla FALSi
        STARTing (points) ##.# (##.#)
        MAXImum (EVALuations) ##
        EPSIlon ##.#
        VALUe (at) ##.#,##.#,....
        EQUAtion 'Y=function of X'
        DYDX 'YPRIME=function of X'
        CLEAr
        EXECute
```

For example, a flag called METHOD% is used to keep track of which method is used. A second flag keeps track of the number of starting points currently entered. An error message would be printed if, for example, the interval-halving method were attempted using only one starting point.

The full version of the functional definitions is used to assist in writing the program. A condensed text version, saved on the disk in a file called "______ROOT", is used to assist the user (see listing 2). The blank in the filename is the prefix. This prefix consists of the first four letters of the major program name, NUMR in this case, because it is planned as part of a

numerical-analysis package.

A list of errors should also be planned to catch mistakes and omissions in input. The list for the sample module is given in listing 3. It attempts to cover almost any input error and also checks that necessary information has been entered. Be sure to rewrite and revise the tree, the HELP list, and the error listing several times before starting to write the code.

Before we proceed, note that in all the development done so far, very little time has been spent on planning the actual program code (other than choosing a few needed flags). All the steps so far have concentrated solely on the problem to be solved, not on the programming language to be used. Usually, the first seven steps will take about half of the development time for a module. The extra time spent on planning will save a lot of time later in changing program code and debugging. This emphasis on planning, on examining the problem, and on using terms normally associated with the problem in a phrase or sentence structure is why this type of input is called *Problem Oriented Language.*

8. *Write the program.* During the discussion on writing the program, consult listing 4 and the variables in listing 5. The comments on POL-80 in listings 4 and 5 in part 1 of this series are also important for understanding the explanations below.

Begin by writing the keyword recognition lines and the required action if a match is found. This consists of the following four actions:

- Set the pattern to be matched in AM (line 3200).
- Set the number of letters to be matched in NLET. This may include numbers and one space at the end of the entity.
- Call the matching routine (GOSUB 750).
- Determine if the match was successful (FLAG=1) and perform the required actions accordingly.

Because "ROOTS" will be checked at a higher level (by the program that will call this module), the first keyword we are interested in is "USINg". Its line is

```
3200 AM="USING"
     :NLET=4
     :GOSUB 750
     :IF FLAG=1
        THEN GOTO 4000
```

The first option at line 4000 is now

```
4000 FCD=1
     :AM="NEWTON"
     :NLET=4
     :GOSUB 750
     :IF FLAG=1
        THEN METHOD%=1
               :GOTO 3200
     (Check for the next command on the line)
```

The remainder of the matches for words can be written in a similar manner.

Organizing the Program

The portions written so far can now be organized into a program format. The highest level of matching is located at line 3200, immediately after the initializing statements. Each

Text continued on page 268

Listing 2: *These HELP messages will assist an inexperienced user in working with the ROOTs program.*

```
The ROOTs module is used to find the real roots of any equation.

The following words are always skipped over at any place in the line:
   A
   AN
   THE
   FOR
   AND
   EQUALS
   EQUAL
   IS
   ARE
   OF
Commas(,) and equivalence signs(=) are also skipped.

The options of ROOTs are:

  USINg method

     where the methods are:

     NEWTon                  (Newton's method)
     APPRoximate NEWton      (Approximate Newton's method)
     SECAnt                  (Secant Method)
     INTErval HALving        (Interval Halving Method)
     REGUla FALSi            (Regula Falsi Method)

  STARTing (points) ##.# (##.#)

     sets the start points for the methods.
       Newton's method requires 1 point.
       Approximate Newton's method requires 2 points close together(4.99 & 5)
       Secant Method requires 2 points.
       Interval Halving and Regula Falsi require 2 points that bracket the
            root between them.

  MAXImum (EVALuations) ##

     ## is the maximum number of evaluations before reporting failure to
       meet convergence requirements.

  EPSIlon ##.#

     When ABS(Y)<##.#, the root is considered to be found.

  VALUe (at) ##.#,##.#,....

     will give the value of the current equation at the values of X entered

  EQUAtion 'Y=function of X'

       used to enter the current equation in correct BASIC syntax.

  DYDX 'YPRIME=function of X'

       used to enter the derivative of X needed by Newton's Method,
       using correct BASIC syntax.

  CLEAr

       used to set values of variables to their default values
       equivalent to the following commands

          USINg SECAnt
          STARting 0 1
          MAXImum EVALuations 20
          EPSIlon 0.1
          EQUAtion 'Y=X'
          DYDX 'YPRIME=1'

  EXECute

       causes the root to be found.
```

Listing 3: *Error messages for the ROOTs program. When developing an error-message list, try to anticipate all typical errors.*

```
1521,"Unexpected entity after ROOTs"
1522,"Unexpected name of method after USINg"
1523,"Missing first number after START"
1524,"Both starting numbers are equal"
1525,"Expecting integer (between 2 and 10000) after MAXImum EVALuations"
1526,"Expecting real number (<10) after epsilon"
1527,"Expecting a number after VALUe"
1533,"Missing string after EQUAtion"
1534,"Missing string after DYDX"
1535,"Missing 2 starting values when method requires 2"
1536,"Did not redefine DYDX after changing EQUAtion"
1541,"Failed to decode remainder of line"
9999,"******Last entry in an error list must always be Line 9999*******"
```

Circle 281 on inquiry card.

Listing 4: *ROOTs program listing. ROOTs is designed to work with the POL-80 program.*

```
*******************************************************************************

Module ROOTs

*******************************************************************************
3000 REM MODULE ROOTS(NUMRROOT)
3001 REM COPYRIGHT MARK FINGER 1981
3010 GOSUB 7100                                      **Stores return addresses and
     :FCD=0                                            initializes parameters
3020 FART=1
     :AART(0)="A "
     :AART(1)="AN "
     :AART(2)="THE "
     :AART(3)="IS "
     :AART(4)="ARE "
     :AART(5)="EQUALS "
     :AART(6)="EQUAL "
     :AART(7)="AND "
     :AART(8)="FOR "
     :AART(9)="OF "
     :NART=9
3030 FCOM=1
     :ACOM(0)=","
     :ACOM(1)="="
     :NCOM=1
*******************************************************************************

Matching on the highest level of the tree structure below ROOTs

*******************************************************************************
3200 AM="USING"
     :NLET=4
     :GOSUB 750
     :IF FLAG=1
         GOTO 4000
3210 AM="START"
     :NLET=4
     :GOSUB 750
     :IF FLAG=1
         GOTO 4100
3220 AM="MAXIMUM"
     :NLET=4
     :GOSUB 750
     :IF FLAG=1
         GOTO 4200
3230 AM="EPSILON"
     :NLET=4
     :GOSUB 750
     :IF FLAG=1
         GOTO 4300
3240 AM="VALUE"
     :NLET=4
     :GOSUB 750
     :IF FLAG=1
         THEN FVA=0
              :GOTO 4400
3250 AM="EQUATION"
     :NLET=4
     :GOSUB 750
     :IF FLAG=1
         GOTO 4600
3260 AM="DYDX"
     :NLET=4
     :GOSUB 750
     :IF FLAG=1
         GOTO 4700
3270 AM="EXECUTE"
     :NLET=4
     :GOSUB 750
     :IF FLAG=1
         GOTO 5000
3280 AM="CLEAR"
     :NLET=4
     :GOSUB 750
     :IF FLAG=1
         GOTO 4800
3290 IF FCD=0
        THEN NERR=1521
             :GOSUB 1200
3291 IF FCD=1 AND IEOC=0
        THEN NERR=1541
             :GOSUB 1200
3295 FERR=1
3300 GOSUB 7000
     :CHAIN MERGE ARET,IRET,DELETE 3000-9999
*******************************************************************************

Matching for the method under USINg

*******************************************************************************
4000 FCD=1
     :AM="NEWTON"
     :NLET=4
     :GOSUB 750
     :IF FLAG=1
         THEN METHOD%=1
              :GOTO 3200
4010 AM="APPROXIMATE"
     :NLET=4
     :GOSUB 750
```

Listing 4 continued on page 264

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Listing 4 continued:

```
        :IF FLAG=1
            THEN AM="NEWTON"
                 :NLET=4
                 :GOSUB 750
                 :METHOD%=2
                 :GOTO 3200
4020 AM="SECANT"
        :NLET=4
        :GOSUB 750
        :IF FLAG=1
            THEN METHOD%=3
                 :GOTO 3200
4030 AM="INTERVAL"
        :NLET=4
        :GOSUB 750
        :IF FLAG=1
            THEN AM="HALVING"
                 :NLET=3
                 :GOSUB 750
                 :METHOD%=4
                 :GOTO 3200
4040 AM="REGULA"
        :NLET=4
        :GOSUB 750
        :IF FLAG=1
            THEN AM="FALSI"
                 :NLET=4
                 :GOSUB 750
                 :METHOD%=5
            :GOTO 3200
4050 NERR=1522
        :GOSUB 1200
        :GOTO 3295
*******************************************************************************

Setting the number of STARting POINTs and their values

*******************************************************************************
4100 FCD=1
        :FT=1
        :GOSUB 950
        :IF FLAG=1
            THEN X1=DV
                 :FSP=1
                 :GOTO 4150
4110 AM="POINT"
        :NLET=4
        :GOSUB 750
        :IF FLAG=1
            GOTO 4100
4120 AM="AT "
        :NLET=3
        :GOSUB 750
        :IF FLAG=1
            GOTO 4100
4140 NERR=1523
        :GOSUB 1200
        :GOTO 3300
4150 FT=1
        :GOSUB 950
        :IF FLAG=0
            GOTO 3200
4160 X2=DV
        :FSP=2
        :IF X2<>X1
            GOTO 3200
4170 FSP=1
        :NERR=1524
        :GOSUB 1200
        :GOTO 3295
*******************************************************************************

Setting the number of MAXImum EVALuations

*******************************************************************************
4200 FCD=1
        :FT=3
        :BB1=2
        :BB2=10000
        :GOSUB 850
        :IF FLAG=1
            THEN NUMEVAL=IV
                 :GOTO 3200
4210 NERR=1525
        :GOSUB 1200
        :GOTO 3295
*******************************************************************************

Setting the value of EPSIlon

*******************************************************************************
4300 FCD=1
        :FT=3
        :BB1=1E-20
        :BB2=10
        :GOSUB 950
        :IF FLAG=1
            THEN EPSILON=DV
                 :GOTO 3200
4310 NERR=1526
        :GOSUB 1200
        :GOTO 3295
```

Listing 4 continued on page 266

WHAT IS THE TRUE COST OF A DISKETTE?

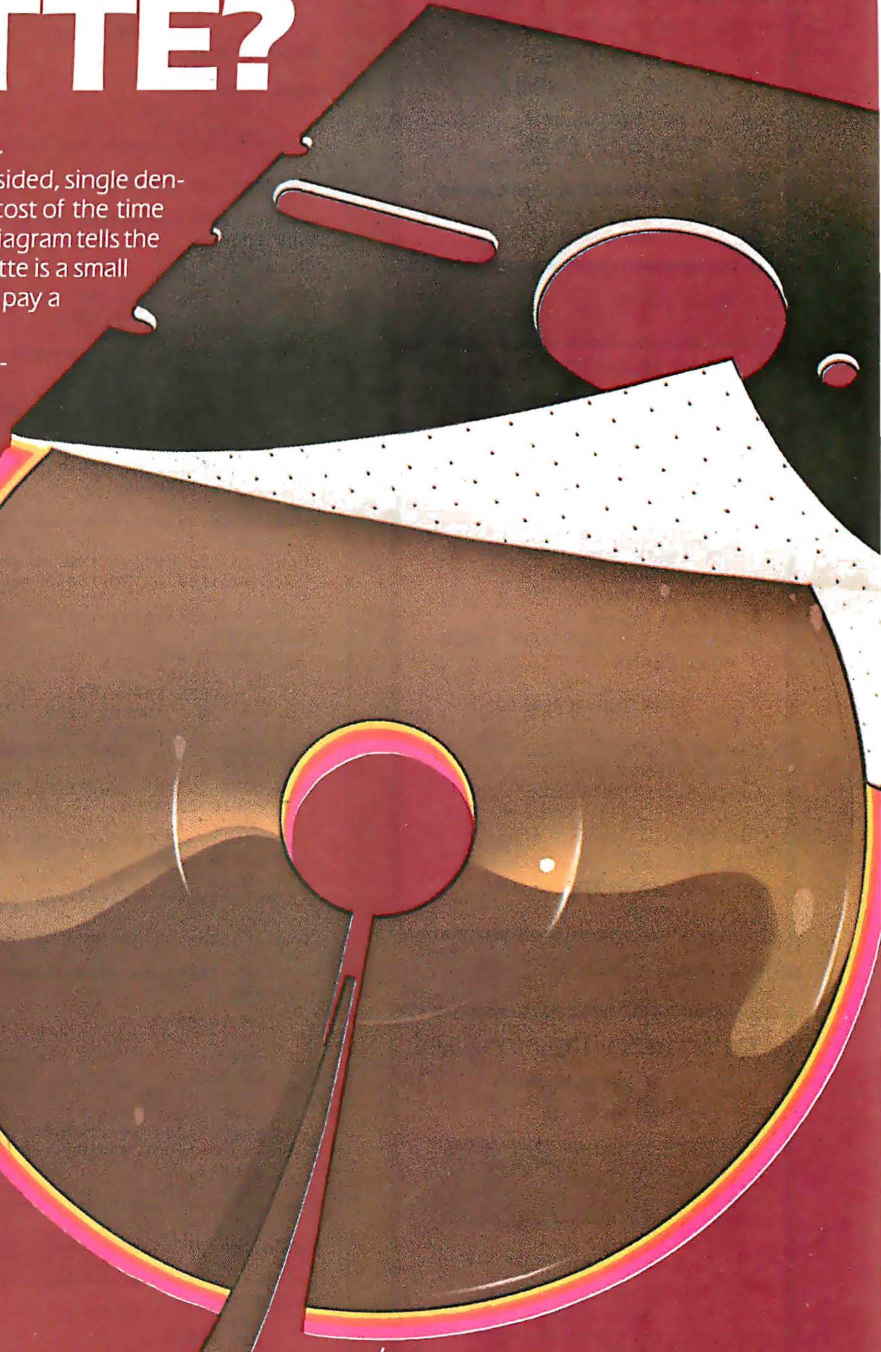
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Listing 4 continued:

```
********************************************************************************

Returning the value(s) of Y at the requested X('s)

********************************************************************************
4400 FCD=1
4430 AM="AT "
     :NLET=3
     :GOSUB 750
     :FT=1
     :GOSUB 950
     :IF FLAG=1
         THEN FVA=1
              :X=DV
              :GOSUB 9000
              :PRINT "The value at ";X;" is ";Y
              :GOTO 4430
4440 IF FVA=1
        GOTO 3200
4450 NERR=1527
     :GOSUB 1200
     :GOTO 3295
********************************************************************************

Entering the EQUAtion

********************************************************************************
4600 FCD=1
     :GOSUB 800
     :IF FLAG=0
         THEN NERR=1533
              GOSUB 1200
              GOTO 3295
4610 AEQ="9000 "+AB+":RETURN"
     :FEXT=0
     :FDX=0
4620 OPEN "O",#7,"EQUATION.BAS"
     :PRINT#7,AEQ
     :CLOSE#7
     :CHAIN MERGE "EQUATION",4630,ALL,DELETE 9000
4630 GOSUB 1480
     :GOTO 3200
********************************************************************************

Entering the derivative of the equation
    (required by Newton's method)

********************************************************************************
4700 FCD=1
     :GOSUB 800
     :IF FLAG=0
         THEN NERR=1534
              :GOSUB 1200
              :GOTO 3295
4710 AEQD="9001 "+AB+":RETURN"
     :FDX=1
4720 OPEN "O",#7,"EQUATION.BAS"
     :PRINT#7,AEQD
     :CLOSE#7
     :CHAIN MERGE "EQUATION",4630,ALL,DELETE 9001
4730 GOSUB 1480
     :GOTO 3200
********************************************************************************

CLEAring the parameters to default values

********************************************************************************
4800 FCD=1

     :METHOD%=3
     :X1=0
     :X2=1
     :FSP=2
     :NUMEVAL=20
     :EPSILON=.1
     :AEQ="9000 Y=X:RETURN"
     :AEQD="9001 YPRIME=1:RETURN"
     :FDX=1
     :GOTO 3200
********************************************************************************

EXECution of root-finding

********************************************************************************
5000 FCD=1                                          **Initializing values
     :X=X1
     :IF FSP=2
         THEN X=X2
              :GOSUB 9000
              :YLAST=Y
              :XLAST=X
              :X=X1
5010 IF METHOD%<>1 AND FSP<>2                       **Checking for 2 starting
        THEN NERR=1535                                points for methods that
             :GOSUB 1200                              require 2
             :GOTO 3295
5020 IF METHOD%=1 AND FDX=0                         **Checking for derivative
        THEN NERR=1536                                update if Newton's method
             :GOSUB 1200                              is used
             :GOTO 3295
```

Listing 4 continued on page 268

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Listing 4 continued:

```
5030 IF METHOD%=4
        THEN GOSUB 9000
            :XOTHER=X
            :YOTHER=Y
5050 NUM=0
5100 NUM=NUM+1                                      **Computation loop
     :ON METHOD% GOSUB 6000,6200,6400,6600,6800
5110 XOTHER=XLAST                                   **Adjusting to maintain the
     :YOTHER=YLAST                                    points for the next time
     :XLAST=X                                         through the loop
     :YLAST=Y
     :X=XNEW
     :Y=0
5200 IF NUM>NUMEVAL                                 **Checking if too many
       GOTO 5400                                      evaluations
5210 IF ABS(YLAST)>EPSILON                          **Checking if done
       GOTO 5100
5220 PRINT "The root is ",XLAST                     **The desired root has been
     :PRINT NUM;" Evaluations were required."         found
5260 GOTO 3200
5400 PRINT "The root was not found in ";NUMEVAL;" attempts."
5410 PRINT "The last values were X =";XLAST;" and Y =";YLAST
5420 GOTO 3200
*******************************************************************************
Methods Subroutines
*******************************************************************************
6000 GOSUB 9001                                     **Newton's Method
     :GOSUB 9000
     :XNEW=X-Y/YPRIME
     :RETURN
6200 XOTHER=X                                       **Approximate Newton's Method
     :X=X+(X2-X1)
     :GOSUB 9000
     :YLAST=Y
     :XLAST=X
     :X=XOTHER
     :GOSUB 9000
     :XNEW=X-Y/((YLAST-Y)/(XLAST-X))
     :RETURN
6400 GOSUB 9000                                     **Secant Method
     :XNEW=X-Y/((YLAST-Y)/(XLAST-X))
     :RETURN
6600 X=.5*(XLAST-XOTHER)+XOTHER                     **Interval Halving Method
     :GOSUB 9000
     :IF Y*YLAST>0
        THEN XLAST=XOTHER
            :YLAST=YOTHER
6610 XNEW=X-Y/((YLAST-Y)/(XLAST-X))
     :RETURN
6800 GOSUB 9000                                     **Regula Falsi Method
     :XNEW=X-Y/((YLAST-Y)/(XLAST-X))
     :XLAST=XOTHER
     :YLAST=XOTHER
     :RETURN
*******************************************************************************
Subroutine for saving variables when leaving
*******************************************************************************
7000 OPEN "O",#6,ADISK+"SAVEROOT"
     :WRITE#6,AEQ
     :WRITE#6,AEQD
     :WRITE#6,EPSILON,FCD,FDX,FSP,FVA,METHOD%,NUMEVAL,X1,X2
     :CLOSE#6
     :GOSUB 1400
     :RETURN
*******************************************************************************
Subroutine for restoring variables when returning
*******************************************************************************
7100 OPEN "I",#6,ADISK+"SAVEROOT"
     :INPUT#6,AEQ
     :INPUT#6,AEQD
     :INPUT#6,EPSILON,FCD,FDX,FSLP,FVA,METHOD%,NUMEVAL,X1,X2
     :CLOSE#6
7110 OPEN "O",#7,"EQUATION.BAS"
     :PRINT#7,AEQ
     :PRINT#7,AEQD
     :CLOSE#7
     :CHAIN MERGE "EQUATION",7120,ALL,DELETE 9000-9001
7120 GOSUB 1450
     :RETURN
*******************************************************************************
Equation subroutines will be inserted here
*******************************************************************************
9000 REM
9001 REM
*******************************************************************************
Remember--
  Line 9999 must be present in the module, even if only as a remark.
*******************************************************************************
9999 END
```

Text continued from page 258:

successful match, except for EXECute, directs the computer to a line in the 4000s for further processing on that branch. For example, lines 4000 to 4050 handle matching for the methods and set a flag (METHOD%) for internal use by the program. Each of the other keywords, at the same level in the tree as USINg, has its own sections for further processing.

Error Trapping

What happens if someone goofs and misspells a word or simply gets a wrong word? Line 3290 checks for this. A flag (FCD) is set to 0 upon entering this module. A successful match on any of the acceptable words results in FCD being set to 1 (see lines 4000, 4100, etc.). If line 3290 is reached, we may or may not have a problem. If the end of the current command has been reached, and we have already found at least one valid command (FCD=1), we may return to the calling program. If no valid keyword has been found (FCD=0), or if we have not reached the end of the current command, implying that there are more words to be processed, we have an error.

One of the variables (FEOC) in the POL-80 program is set whenever an end-of-command is reached. It can be examined as needed. If an error is found, an error number is set, a message is printed (the subroutine at line 1200), the remainder of the current command line is ignored (FERR=1), and control is returned to the calling module or main program (line 3300). Each error in the ROOTs program is handled similarly; line 4050, for example, is reached if an acceptable root-finding method is not chosen.

Variations in Input

Not all input is in words, however. Sometimes a number is required, for example, the maximum number of evaluations for MAXImum EVALuations. Line 4200 in ROOTs shows the steps required to extract a number. The type of number is set by FT. In this case FT is positive, implying that either an integer or a real value is ac-

Listing 5: *Variables and their descriptions as used in the ROOTs program.*

AEQ	Internal equation containing the root to be found	Default is "Y=X"
AEQD	Contains the derivative of AEQ	Default is "YPRIME=1"
EPSILON	The value for determining success of finding root--success if ABS(Y)<=EPSILON	Default = .01
FCD	Flag for checking command syntax	
FDX	Flag for making sure a new AEQD is entered if AEQ is changed (required for Newton's Method)	
FSP	Number of starting points entered	Default = 2
FVA	Flag for syntax after VALUe (AT)	
METHOD%	Flag for method to be used	Default=3 (Secant)
NUMEVAL	Maximum number of attempts (to find root) before failure is declared	Default=20
X	Independent variable in AEQ and AEOD	
X1	Starting point 1	Default = 0
X2	Starting point 2	Default = 1
Y	Dependent variable in AEQ	
YPRIME	Dependent variable in AEQD	
XOTHER	A previous X value attempted	
YOTHER	Y value at XOTHER	
XLAST	Another previous X value attempted	
YLAST	Y value at XLAST	
XNEW	X value for next attempt	

ceptable, but that it should be rounded to the nearest integer. Acceptable values are between 2 and 1000. Because other values are not acceptable, FT is set to 3. An error is set if the number is not in the proper range. Lines 4100, 4300, and 4535 show other examples of extracting numbers.

Sometimes strings are required. In ROOTs, strings may be required for the equation and its derivative (lines 4600 to 4630 and 4700 to 4730, respectively). To get a string, GOSUB 800 is called. If the current entity is a string, it returns FLAG=1, and the string is stored in AB. Because the string represents an equation we wish to use in the program, a line of BASIC code is built up as a subroutine by placing one of the reserved line numbers, 9000 or 9001, at the beginning of the string and a RETURN at the end. The line of code is stored in a BASIC program file. Then, that line is put into the current program using CHAIN MERGE, and the files are reset.

Although it is not done in ROOTs, a match may be done on a specific character, if desired, by using GOSUB 750 as if a word that is one character long were being matched (NLET=1).

The portions of the program discussed so far can be directly tied to the "tree" and the HELP listings. Because each keyword has very specific actions associated with it, the actual coding is relatively simple. Standard sequences for matching or extracting entities are used; normally, one or two flags or values are set, or an error may be set. Compare lines 3200 to 5000 with the tree. What seems complex is actually simple when examined in detail. The difficult part of programming in POL is designing the input and writing the tree (steps 3 to 6 above).

Lines 5000 to 7000 form the main computational section. Flags are first checked and appropriate actions taken, then the computational loop is started (lines 5100 to 5210). The two possible endings are handled in lines 5220 to 5420. Lines 6000 to 7000 contain the subroutines for the five root-finding methods.

Finally, initialization routines are required. Lines 3010 to 3030 and the subroutine at line 7100 do initialization on a normal entry, while line 3300 and the subroutine at line 7000 handle return to the main program. The procedures in these lines are a minimum set for a simple module.

Summary

This part of the series has presented a step-by-step procedure for writing an individual module. In part 3, we will look at the relationship between modules, how to write the main program that links modules, and ways in which modules can be made more useful. I will also present a more flexible and comprehensive method of entering and exiting modules. ■

The following items are available from the author:

1. The POL/PS User's Manual *and the* ROOTs User's Manual *for $20. These manuals generally supplement but do not duplicate the material presented here. Topics include detailed rules of input, theory and examples of operation, and programming rules and hints.*
2. *The two manuals above and a disk containing all the appropriate files for $30.*
3. *The items listed above and the graphics package (which includes the contour plotter module) for $200. The ROOTs module in this package will have additional graphics capabilities, such as plotting the equation and graphically following the root-finder as it seeks the root.*

These items will be offered on several disk formats (CP/M 8-inch, Osborne, and others as I can make arrangements). A user's group will be set up, and I will sell software written by others for the POL/PS on a royalty basis. For more information, or to order items, contact:

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Program Development System I
Program Writer for Non-Programmers
Programming Aids 3.3
Quic-N-Easy Application Development
RAID-Real Time Assembly Debugger
Scientific Data Base
SID-Symbolic Instruction Debugger
Stok Pilot-Menu Generator
STRING-80
STRING-BIT
Systems Analyst
Teacher Plus Teaching & Reference Pkg
The BASIC Teacher
The Last One-Program Generator Pkg
The Toolbox Programming Utilities
Tiny-C-Interactive Programming
UCSD Pascal
Unlock Development Tool
V-COM Disassembler Package
Z8000 Cross Assembler

BUSINESS MANAGEMENT TOOLS

Analyst-Business Productivity
Apple Sack General Business Program
Bookkeeper II-Sales Analysis
Business Pac 100
Business Planner
Creative Financial Package
Desktop/Plan
Execuplan Planning & Forecast
Financial Modeling System
Financial Planning Series
Financial Planning/Analysis
Finplan/Financial Planning
FP2020 Financial Planner
FPL-Financial Planning Language
Magic Worksheet
Magicalc-Forecasting Package
Micro-DSS/Finance
Microfinesse-Financial Modeling
Milestone-Critical Path Network Analysis
Optimiser
PFS-Personal Filing System
Personal Report System
Plan 80-Financial Planning & Analysis
Project Boss-Mgr's Cost Control System
Project Planning and Budgeting
Retail Purchasing & Pricing
Salary Planner
Senior Analyst
Supercalc-Electronic Spread Sheet
Support Pkg for Real Estate Mgmt
T/Maker II-Visual Calculating Tool
The Analyzer
The Budget Planner
Universal Business Machine Planning and Forecasting
VisiCalc III
VisiCalc Real Estate Template

CAPITAL PROJECTS PLANNING & CONTROL

Angle Project Scheduling
APM-Project Management System
Jobtrak-Project Tracking
Milestone Project Management
Project Management System
Project Planning

COMMUNICATIONS

Apple Access III
BISYNC-80
BSTAM
Class Data Recorder
CM-900 Burroughs Network Services
Communications Program
Crosstalk Smart Terminal/File Transfer
Data Capture 4.0
Data Transporter Package
Datalink
DTS-3-Serial Data Transfer
Electronic Mail
IBM-CP/M Allows Transfer of Data
IE/Modem
Intercom Communications
METTY-Intelligent Terminal Package
Micro-Courier
Micro-Telegram
Microlink-80-File Transfer Program
Reformatter-CP/M-IBM Data Transfer
Remote Console Program
Smarterm-CP/M Terminal Program
Term II-Computer Intercommunications
Term Intercommunications Package
TTY-Communications With Other Computers
U-Net-Shared Resources Network
Ultimate Transfer
Visiterm-Communications Program
VT-100 Emulator
Western Union Interface

DATA MANAGEMENT

ANALYST
CBS-Configurable Business System
CCA Data Mgt System
CM 2020 Configurable Manager
Condor Series 20
Data Management Program
Data Manager
Data Master
Data-View Electronic Filing Cabinet
Database II
Database Management
Datafax
Dataflow-Info Processing
Datastar
Datastore
Datatree
Disk-Edit-Screen Oriented Disk Editor
DMS-Data Mgmt System
FABS II-Rapid Keyed Access
Fast Entry for Tabs Business Modules
FINDAFYL-Reference Retrieval System
FMS 80-Data Base Management System
GBS Database
General Database
HDBS-Hierarchial Data Base
IFO Database Manager
Information File Organizer
Information Master-Data Mgmt System
KTDS-Key to Disk, Data Entry
Linkindex-Pascal Utility
MAG/Base-Data Base Management
Manager-Relational Data Base
MDBS.DRS-Micro Database Mgt System
MUMPS-Language for CP/M Database
Optimum Data Mgmt Program
PRISM/IMS-Information Mgt System
RADAR-Random Access Data Acquisition
Reprogrammable Data Base
Scientist-Data Base & Statistical Pkg
Selector III-Data Base Processor
Selector IV-Data Base Mgt
Selector IV-Key Access Info
Selector V-Data Base Mgmt
STATPRD-Integrated Database System
Stoneware Utility Package
Super Kram II — Multi-Keyed Random Access
The Reprogrammable Data Base Program
VisiDex-Data Base Mgt System
VisiFile-Data Base Mgt Package
Whatsit?-Conversational Query/Retrieval

DATA SECURITY SYSTEMS

Absolute Security
Encode/Decode Security System

DISTRIBUTION

ABT Retail Manager
Beer Distributor Management
Inventory, Order Entry, Invoicing
Oil Jobber Management System
Order Entry and Inventory Control
The Store Manager
Wholesale/Retail Distribution System

EDUCATION — BUSINESS

Accounting Tutor
Comparative Buying
Income Meets Expenses
Interactive Typing Tutor
Job Readiness-Assessment & Development
Mastertype-Typing Instruction
Money Mgmt Assessment
Typing
Typing Tutor
You Can Bank On It-Bank Concepts

EDUCATION — CHEM/PHYSICS

Acid-Based Chemistry
Atomic Structure
Chem Lab Simulation
Chemical Equilibrium
Chemistry With A Computer
Fundamental Skills for General Chemistry
High School Chemistry
High School/Jr. College C.A.I. Biology
High School/Jr. College C.A.I. Physics
Organic Nomenclature
Physics

EDUCATION — ENGLISH

A Batch of Endings
Agreement of Pronoun/Antecedent
Alphabetize
Capitalization
Catalog Cards
Commas
Compu-Read
Compu-Spell
Coordination
End Marks
Excess Words
Faulty Coordination
Hearing the Homonyms
Irregular Verbs
Is It "ie or ei?"
Language Drill
Locate Books on the Shelf
Magic Spells
Misplaced Modifiers
Parallel Structure
Possessing the Possessives
Prefixes & Suffixes
Quotations
Reading Level
Readings In Literature
Run On Sentences
Scramble
Sentence Diagramming
Sentence Fragments
Speedreader
Spell-N-Time
Spelling Bee with Reading Primer
Spelling Those Plurals
Still More Nasty Demons
Subject/Verb Agreement
Subordination
The End of the Endings
Those Nasty Demons
Understand the Card Catalog
Understand the Title Page
Use an Index
Use the Table of Contents
Using Adjectives/Adverbs Correctly
Word Scrambler & Super Speller

EDUCATION — MATH

Addition & Subtraction
Algebra I
Basic Math Skills
Compu Math: Arithmetic Skills
Compu-Math Decimals
Compu-Math Fractions
Counting Bee
Decimal Estimation
Division Drill
Drill II
Elementary Math
Fractions
Geometry
Geometry and Measurement Drill
Lessons in Algebra
Matching and Using Numbers
Matching Geometric Figures
Math-Addition & Subtraction
Matrix Mathematics Package
Measurements
Multiplication & Division
Mumath-PO Symbolic Math
New Subtraction
Numerical Analysis Mathematics
Problem Solving
Problem Solving in Everyday Math
Sets
Sign Drill/Typing
Statistical Analysis I Mathematics
Statistics 3.0
Typing Fractions

EDUCATION — MISC.

2ES Courseware
American History Through Biographies
American Indians
Antonyms
Apple Sack 2 Home Education
Approximate Measure
Astronomy I & II
Concentration-Taxing
Counting Calories
Early Civilization
Educational Package
Educator's Disk
Family Fun
Farm and Farm Products
HI-Res Life
History
Home Safe Home
Insects
Light Pen Quiz
Literature
Living Things
Math, Sports, Etc.
Middle Ages
Money
Moptown
Mother Goose Rhymes
Music/Art
Our Bodies
Poison Proof Your Home
Questions & Answers in Biology
Questions & Answers in History
Quizstat
Reverse/Sampling
School Days
Sentence Beginning
Shore Features
Sound
Supermap
Synonyms
Systems of the Body
Teacher Create Series
Teacher Plus
Telling Time
The Basic Teacher Pac
The Earth and It's Composition
The Professional-Teaching Program
The Solar System
Transportation History
Typing
United States
Visual Perception Tests
Weather Fronts
Work Relationships
World Desert Region
World Polar Regions

FINANCE-INVESTMENT & PORTFOLIO ANALYSIS

Analysis 1-Stock Trend Data Analysis
Commoapx System
Computicker
Computrac File Reader
Dow Jones News & Quotes Reporter
Dow Jones Portfolio Evaluator
Dowlog-MC
Electronic Stock Package
Engineer's System For Trading
Forecast I
Forecast II
Fotofolio-Visual Display w/Statistics
Gann's Square of Nine Analysis
Intelligent Investor
Investment Analysis
Market Charter-Technical Analysis
Moneybee-Investment Analyst
Options 80-Stock Options Analyzer
Portfolio Master
Quotecharter
Quoteprocessor
Ratortn-Investment Analysis
Stock and Options Analysis
Stock Forecasting
Stock Market Management
Stock Market Utility
Stock Option Analysis
Stock Tracker
Stock Valuation Program
Stocksheets
Strategy M-Monitor Price Change Dynamics
The Clover Method Trading System
The Stock Portfolio Program
Tickertec-Tickertape Program
Wilers 6 Systems Analysis

FOREIGN LANGUAGES

Chinese Lessons
Foreign Words and Phrases
Greek Roots and Prefixes
Japanese Lessons
Latin Roots and Prefixes
The French Hangman
The Russian Disk
The Spanish Hangman

GAMES

Adventures
Alien Rain
Alien Typhoon
Almanac — The Time Machine
Amaze
Analiza
Animal
Anti-Ballistic Missile
Apple Adventure
Apple Bowl
Apple Fun
Apple Panic
Apple Sack 3 — Adventure Pak
Apple Sack 7 — Space Sack
Apple Sack 8 — Game Sack
Apple Sack 9 — Base Star
Apple Stellar Invaders
Apple-oids
Asteron
Astro-Scope
Astrology
Autobahn
Backgammon 20
Battle of Midway
Beer Run
Best of Muse
Biorythms
Blackjack
Both Barrels
Brands
Bridge 2.0
Bridge Tutor
Bubbles, Planetoids and Burnout
Cartels and Cutthroats
Castle Wolfenstein
Chambers of Xenobia
Chebychev 1
Chebychev 2
Chronicles of Osgroth
Civil War
Compu-Math Arithmetic
Compu-Math Decimals
Compu-Math Fractions
Computer Air Combat
Computer Baseball
Computer Bismark
Computer Conflict
Computer Napoleonics
Computer Quarterback
Cops and Robbers
Cosmo Mission
County Carnival
Cyber Strike
Disk Talker
Dr. Chips
Dragon Fire
Dungeon
Executive Fitness
Falcons
Fantasyland 2041
Fastgammon
Flight Simulator
Galactic Attack
Galactic Wars
Galaxy Wars
Games People Play
Gamma Goblins
Gobbler
Golf/Cross-Out
Gorgon
Hammurabi
Head On Game
Hellfire Warrior
Hi-Res Football
Hi-Res Soccer
In The Army Now
Into Ships
Jet Fighter Pilot
Klondike 2000
Lost By Ship
Mastermind
Meteoroids in Space
Micro Othello
Mimic
Mind Games Package
Mission Asteroids
Mystery House
Need an Analyst
Nominoes Jigsaw
Oil Tycoon
Olympic Decathlon
Operation Apocalypse
Orbitron
Outpost
Paddle Fun
Pegasus II
Perception 3.0
Phantoms Five
Planetoids
Plot 3D
Pokeno
Poker Slot Machine
Pool 1.5
Pot 'O Gold I
Pot 'O Gold II
President Elect
Pro Football
Pro Picks
Project Omega
Pulsar II
Race For Midnight
Raster Blaster
Red Baron
Rendezvous
Robot Wars
Sahara Warriors
Sargon II (Chess)
Satellite Trak
Shell Games
Shuffleboard
Skybombers
Skybombers II
Sneakers
Snoggle
Soft Porn
Softside Publications
Space Eggs
Space Warrior
Spellguard
Spelling Bee
Star Cruiser
Star Dance
Star Thief
Startraders
Startrek
Stock
Sub Attack
Tawala's Last Redoubt
Teacher's Pet
Temple of Apshal
Terrorist
Tetrad
The Strip
The Asteroid Field
The Great Escape
The Horse Selector II
The Prisoner
The Scorekeeper
The Shattered Alliance
The Warp Factor
Three Mile Island
Torpedo Fire
Ultima
Voyage of the Valkyrie
War and Games
War Games
Warp Factor
Watch Your Moves
Win at the Races
World's Greatest Blackjack
Wumpus
Xplode

ME WHAT AN APPLE CAN DO?

GRAPHICS/ COMPUTER-AIDED DESIGN
3-D Surface Plotter Package
A2-3D1 Graphics Family
ABT Barwand Software
Action Sounds & Hi-Res Scrolling
Apple Plot
AppleGraphics II
Artist Designer
Bar Chart (Histogram) Graphics
Business Graphics III
Circuit Designer Graphics
Circuit Simulator
Creativity Tool Box
CURVFIT
Data Plot
E-Z DRAW
FLGDZINE
Graforth – Development Tool
Graph-Fit
Graph-Pak
GRAPHPOWER
Hi-Res Secrets
Line Graphics
MC Painting
ORIFICE
Pascal Animation Tools
Pascal Graphics Editor
Perspective Plot – 3-D Graphics
PGE – Graphics Editing Package
PILOT Animation Toolkit
Polar Coordinate Plot
RGL Real Time Graphic System
Screen Director
Shape Table Generator
Stats-graph
Super Shape Draw & Animate
Tablet Graphics
The Coloring Board Program
The Designer
Topographic Mapping
Ultra Plot
Utopia Graphics Tablet System
VACVESL – Vacuum Vessel Design
VESDZINE – Design of Vessels
VISITREND/VISIPLOT
X-Y Vector Plot Package

HOME MANAGEMENT
Address File
Auto Records
Checkbook Balancing
Checking Account Management
Chequemate
Diet Analysis
Financial Analyzer
Five Minute Financial Check-Up
Grocery List
Home Finance
Home Inventory File
Home Money Minder
Home Purchase Analysis
Magazine File
Mortgage Analysis
Personal Accounting System I
Personal Expense Record
Personal Finance Manager
Personal Financial Planning
Programmed Exercise
The Personal Check Manager

INCOME TAX
Dow Jones Portfolio Evaluator
Individual Tax Planner
Micro-Tax Individual Tax Package
Micro-Tax Integrated State Income Tax
Micro-Tax Partnership Package
SHORTAX – Tax Planning Package
Tax Planner
Tax Preparer
TRPS – Tax Return Preparation System

INVENTORY CONTROL
ARM-1000 – Rental Business
Basic Business Inventory
Bill of Materials
BPI Inventory Control
Intotory Inventory System
Inventory Accounting
Inventory Control
Inventory Management
Inventory Management for Stock Control
Inventory Pac
Inventory System Business Module
Manufacturing Inventory Control
MATSTAT-Materials Tracking
Order Entry/Inventory Control
Peachtree Inventory System
Point-Of-Sale Retail System
Property Manager for Moveable Equipment
Retail Inventory
Rogis Stock Control for Components
Stock Control
Stock Recording
Stockfile Inventory System
Stockroom Inventory and Purchasing
Structured Systems Inventory Control
TCS Inventory Management
The Order Scheduler

JOB & CONTRACT COST ACCOUNTING
Billflow
Bookkeeper II-Job Costing
BPI Job Costing
Contract Billing
Contractor Job Cost
Cost Accountant
Job Accounting System
Job Control System
Job Cost Accounting
Project Cost Accounting for Architects
Project Cost Accounting for Engineers
The Software Fitness Job Cost Analyst
Time Recording-Job Cost Analyst
Timerec-Transaction Carry Forward

MAILING LIST & LABEL PROCESSING
Address Book Mailing List
Apple III Mail List Manager
Apple Mail Sack
Apple Post
Benchmark Mail List
Commercial Mailer
Mail List
Mail80 Mailing List Software
MAILER-Name & Address Management System
Mailing Address
Mailing List Package
Mailing System
MAILMERGE
MAILPRO
Mailroom-Mailing List Management
Master Mailing List
NAD-Name & Address Selection System
Name And Address
Postmaster-Mail Management
Professional Mailout
School Mailer
Small Business Mailing & Filing
Super-M-List Mailing List Program
Ultra Plot/Mailing & Filing System I

MARKETING/SALES ANALYSIS
EASYTRAK-Salesmen Monitoring Package
Marketing Systems – Proposal Developer
Office and Agent Productivity Package
Sales Analysis
Sales Pro Prospect Mgt Package
Sales Tracker
SALESLOG – Sales Mgt Program
SNAP – Questionnaire Design and Printing
TCD Life Insurance Computer System

MISCELLANEOUS
BILL – Building Energy Use
Circuit Analysis
Hand Holding BASIC
Insulate
Mini-Warehouse System
Stepwise Multiple Regression

MUSIC
Alpha Syntauri Music Synthesizer
Apple Music Theory
Apple Sack Music & Graphics
Appleodion Music Synthesis System
Music System
Musicomp
The Electric Duet

ORDER ENTRY/ ACCOUNTS RECEIVABLE
BPI Accounts Receivable Program
Cash Receipts System
Company Sales
Invoice Compiler
Invoicing
Membership Billing
MICROREC
Multi-Property Accounts Receivable
Open Item Accounts Receivable
Order Entry
Order Entry and Billing
Order Entry and Invoicing
Order Tracking System
Peachtree Accounts Receivable
Peachtree Sales Invoicing
Progressive Billing
Purchase Order System
Receivables System Business Module
Receiver
Sales Invoicing
Sales Ledger
Sales Order Processing
Software Fitness Program – A/R System
Structured Systems Accounts Receivable
T-SOP Sales Order Processing
TCS Accounts Receivable Package
TCS Total Receivables
The Biller

PAYROLL PROCESSING
Advanced Payroll Package
After-The-Fact-Payroll – updates records
Apple Payroll System
Bookkeeper II-Payroll
BPI Payroll
Business Basic Payroll System
Contractor Payroll
Jobcost Payroll
Micropayroll
Passive Payroll
Paymaster
Paymaster-Payroll System
Payrecord I
Payroll
Payroll Accounting Package
Payroll Assistant
Payroll I
PeachPay
Piece Rate Payroll System
Post Facto Payroll
Print/Paycheck Accounting System
Run Time Payroll Program
Sheltered Workshop Reporting
Structured Systems Group Payroll
TCS Payroll Package
TCS Total Payroll
Variable Worker's Compensation
WH-347-Accessory program for Jobcost

PERSONNEL MANAGEMENT
AMI Post-Facto Payroll
MICROPERS – Payroll & Personnel Mgmt
Personnel Data Recorder
Personnel Office – Federal Compliance
Personnel Record
Personnel Record/Employee Records System

PROFESSIONAL OFFICE SYSTEMS
AMI Omegabyte Time & Billing
BETA – Stand Alone Time & Billing System
Billkeeper – Professional Billing
Client Billing System
Client Record/Bill Preparation
Datalaw System 3-Law Office Mgmt
DataTime
Dental 80A-Dental Accting & Billing
Dental Billing Package
Dental Office Management
DentalEase
Dentistaid – Dentist Office Management
Insyst (Insurance System)
Legal Billing & Timekeeping System
Legal Clerk – Office Management System
Legal Time Accounting System
Medicaid Day Treatment
Medical Accounting and Billing
Medical Clinic
Medical II – Office Mgmt System
Medical Office Management
Medical Secretary
Medical/Dental Management System
Medical/Manager
MedicalEase
MedPak
Medtips – Billing & Insurance Forms
PAS – 3-Patient Billing & Accts Receivable
Patient Accounting System
PIP-Payroll/Invoicing Program
Professional Office Management
Professional Time & Billing
PTA – Professional Time Accounting Pkg
Series 8000 Dental Mgmt
Series 8000 Medical Mgmt
Series 9000 Family Dental Management
The Patient Scheduler
Timeclok
Timemaster – Time Accounting
Timesaver Client Billing System

PROGRAMMING LANGUAGES
Ada Compiler
APL/V80 Language
Apple III Business Basic
Apple III Pascal
Apple FORTRAN
Apple Logo
Apple PILOT
ASM 65-Assembler
BASIC A+ – Extended Business Basic
BASIC Compiler
BASIC-80
BASIC/Z – Native Code Compiler
BD Software "C" Compiler
C Compiler
CBASIC 2 Compiler
CIS COBOL
COBOL 80
Cos Assembler
Cos COBOL
Focal 65-High Level Programming
Forth 86
Forth-Language Compiler
FORTRAN 80
FORTRAN IV
Hand Holding BASIC
KBASIC – Microsoft Disk Extended BASIC
Language System with Apple Pascal
LISP-80 Compiler
MAC 8080 Macro Assembler
MULISP Compiler
MULISP/MUSTAR 80
muMath/muSimp 80-High Level Programming
Nevada COBOL Compiler
Pascal Compiler
Pascal/M86
Pascal/MY+With SPP-ISO Standard
PL/1-80-Programming Language
RATFOR – FORTRAN Language
S-BASIC
SSS FORTRAN Compiler
Softronics
Stiff Upper Lisp
TCL Disk BASIC Interpreter
TCL-Pascal
TEC 65-Editing Language
Tiny BASIC High-Level Language
Tiny C
Tiny Pascal
Tiny-C-Two Compiler
Transform II
UCSD Pascal
Whitesmith's Compiler
XPLO-Structured Language
XY BASIC Interactive Process Control

PROGRAMMING UTILITIES
Apple Sak 4 – Utility Package
Basic Utility Disk
Disk Utilities 3
Disk Utility Package
Disk-o-Tape-Pascal
DOS Tool Kit
File Maintenance Package
MAG/Sam Keyed File Mgmt System
MAG/Sort-Record Sort
Masterdisk-disk Sector Editor
MSORT – for COBOL 80
Pascal Utility Library
Pascal – Sort Program
PSORT – Pascal File Sorting
QSORT – Sort/Merge Program
SORT/B – Hybrid Sort
Supersort
Ultrasort

PURCHASING/ACCOUNTS PAYABLE
Accounting Payable
Accounts Payable Business Module
Accounts Payable/Purchase Order
Bookkeeper II – Accounts Payable
Cash Disbursements Posting System
Check Writer
Company Purchases
Contractor Accounts Payable
Disk-O-Check
Micropay-Accounts Payable
Print Check Accounting System
Purchase Ledger
Structured Systems Group Accts Payable
T-POP – Purchase Order Processing

REAL ESTATE
American Software Property Management
Apartment Building Investment Analysis
Apartment Manager
Commercial Property System
Construction Cost/Profit Analysis
Cornwall Apartment Management
Income Property Analysis
Listings
Multi-Property Accounting System
Office/Apartment Real Estate Management
Property Analysis System
Property Management
Property Management System
Property Mgmt – G/L Tenant and Expenses
Real Estate Analysis Program
Real Estate Analyzer
Realty Package
Rent vs. Buy
Rental Manager
Residential Property Management
Tax Deferred Exchange Model
Tenant Processing Package
The Landlord-Property Mgmt System
VisiCalc Real Estate Templates

TIME MANAGEMENT & SCHEDULING
Agenda Files
APM – Project Scheduling
Appointment Calendar
Color Calendar Package
Datebook Appointment Calendar
Datebook Time Management System
GUARDIAN – Computerized Scheduling
Office Manager – Staff Appointments
Personal Datebook
Professional Secretary
PROSCHED – Project Schedule
Time Manager

WORD PROCESSING
Apple World Oriented Text Editor
Apple Writer II
Apple Writer III
Benchmark – Word Processing System
Docuwriter Text Processor
Easywriter Word Processing
EDITRIX 1.0 – Word Processing
Form Letter Module
Formulex – Business Form Design
Goodspell
Letter Master – Basic Word Processor
Letteright Correspondence Processing
Letterite Word Processing System
Magic Spell – 20,000 Word Dictionary
Magic Wand – Phrase Insertion
Magic Wand – Word Processor
Magic Wand Word Processing System
Magic Window Word Processor
MAIL-MERGE-Wordstar Enhancement
Manuscripter – Word Processor
Master Text Processor
Memorite III Word Processing
Microspell Spelling Corrector
PALANTIR – Word Processing and Accounting
Personal Text Processing
Report Writer – Word Processing
Script III
Secretary – Word Processing
Spellbinder Word Processing
Spellguard
Super-Text Word Processing
Supertext II
TEXTWRITER III – Text Formatting Program
The Word Spelling Checker
VTS-80 CP/M Word Processing
WordIndex
WordMaster – Comprehensive Editor
Word Master Text Editor
WordStar – Word Processing

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Book Reviews

Teletext and Videotex in the United States

John Tydeman, Hubert Lipinski, Richard P. Adler, Michael Nyhan, and Laurence Zwimpfer
Data Communications
McGraw-Hill Publications Company
New York, 1982
314 pages, hardcover
$30

Reviewed by
Rich Malloy
Technical Editor

Back in 1974, a British research engineer named Sam Fedida displayed a working model of a new telecommunications system that he called viewdata. The basic idea of the system was to attach an inexpensive converter to a home television set and thereby enable viewers to access tremendous amounts of data stored on huge central computer systems. This system would enable people to retrieve information, send messages, make banking transactions, and calculate their income tax, all in the privacy of their homes.

Fedida's effort resulted in the British telecommunications system called Prestel, which was started in 1979 and now has 15,000 subscribers. The name viewdata has since been replaced by the generic term *videotex*, now defined as any two-way data communications link between a host computer and a low-cost terminal (usually a home television with an attached decoder using telephone lines for communication).

Shortly before Prestel was put into service, a videotex system was started by the Canadian government. This system, called Telidon, allows high-quality graphics because it has much sharper resolution than the British system, but it requires a more expensive decoder. In 1980 several other countries, including France, West Germany, the Netherlands, Austria, and Japan, began testing their own videotex systems—usually slight variations of the British Prestel system.

Meanwhile, a similar technology called *teletext* was also developing. In teletext, home television sets can receive news and other data from a host computer via a one-way communications link—usually part of a broadcast television channel. Because it requires a less expensive decoder, teletext has become much more popular than videotex. Two British teletext systems, Ceefax and Oracle, have over 300,000 subscribers.

But what about the United States? What is the present state of videotex and teletext development here? How will these new technologies work, and, perhaps more important, how much will they cost? *Teletext and Videotex in the United States* answers all of these questions and many more.

From the authors we learn that AT&T has developed in the U.S. a new videotex and teletext protocol called North American Presentation Level Protocol (NAPLP), which is an expanded version of the Canadian Telidon system. The authors report that several experimental projects are being conducted throughout the U.S. using either the Prestel or the NAPLP system. Also, a rudimentary teletext service (National Captioning Institute closed captioning) now provides captioning for about 40,000 hearing-impaired television viewers.

Tydeman et al. have done a very thorough job of collect-

ing almost all the information necessary to make informed decisions about videotex. Their book is aimed at "corporate, trade, consumer, and government decision makers," and a major portion of the book is indeed devoted to public policy issues. This may be the first time that the implications of a new technology have been so well examined so early in its development.

The book contains many interesting facts not only on videotex but also on every technology associated with videotex, including computers, telephone networks, cable networks, and television broadcasting. For example, the authors note that different technological advances have been accepted at different rates. It took 70 years before even half of all U.S. households had telephones, but television was in 75 percent of all households in just 11 years.

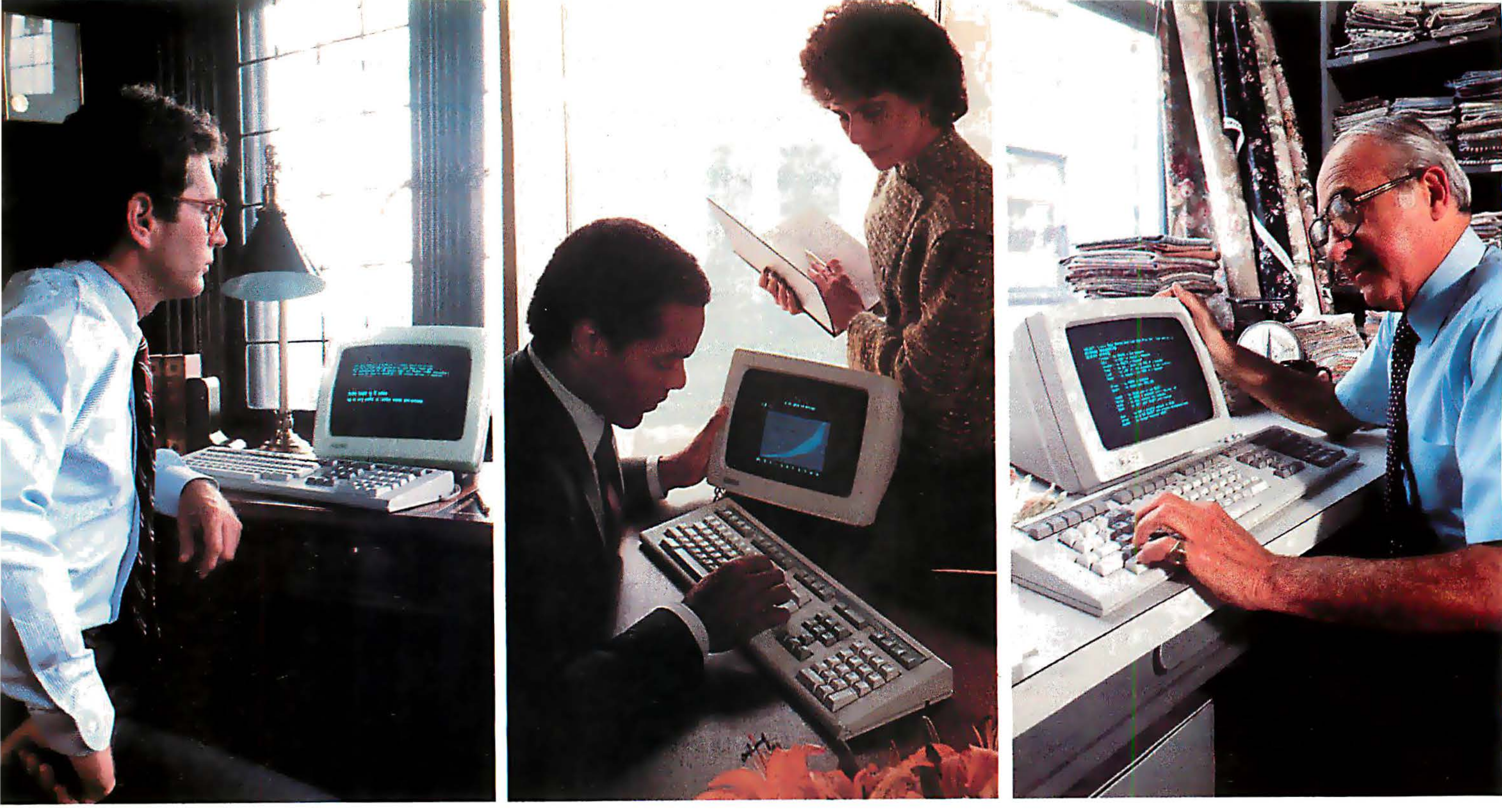
One of the problems with videotex as it now stands is the tendency of its proponents to regard personal computers merely as hobbyists' devices. Tydeman et al. are more open-minded than most in that they treat personal computer networks such as The Source, Compuserve, and Dow Jones News Retrieval Service as bona fide videotex networks. Actually, the total number of subscribers to these services (77,000) is more than twice the number of videotex subscribers in the rest of the world combined.

The book contains many interesting facts on videotex and every technology associated with it.

The book unfortunately does fail to explore three important points about the potential of personal computers and videotex: (1) Whichever standard (Prestel or NAPLP) is adopted in the U.S., personal computer users will probably be able to use either one. (2) For the same price as a videotex decoder, a person could buy a personal computer that can do all that a videotex decoder can do plus much more. (3) Personal computer users will be able to generate, not just receive, videotex images.

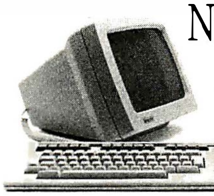
Another complaint about the book is that parts of it read as if it had been written by committee. Indeed, the book is the result of a study by a California group called the Institute of the Future and was sponsored by the National Science Foundation. Perhaps as a consequence of this, some of the sentences are a bit long-winded: "The aim of the policy analysis is to provide a context for policymakers to assess their role in the emergence of teletext and videotex services."

Overall, though, the book is a very valuable reference for anyone involved in communications and, in one sense or another, that includes just about all of us. In fact, the book has been so popular that its first printing sold out in about two months. It's also extremely timely; the publisher has done an excellent job getting the book out while the information is still current. If you're professionally involved with communication or just want to know what all the fuss is about, *Teletext and Videotex in the United States* should answer virtually all of your questions.■



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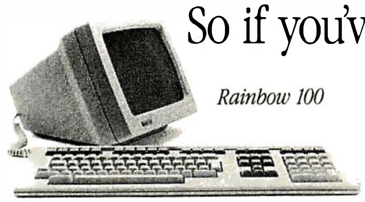
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Book Reviews

Structured Systems Programming

Jim Welsh and R. Michael McKeag
Prentice-Hall Inc.
Englewood Cliffs, NJ,
1980
324 pages
hardcover, $26

Reviewed by
David D. Clark
246 South Fraser St.
State College, PA 16801

Whether you're a hobbyist or a professional programmer, at some point you'll probably toy with the idea of writing a compiler or operating system tailored to your needs. And when you do, *Structured Systems Programming* may be your most valuable guide. Part of the Prentice-Hall International Series in Computer Science, the book explains how to apply structured techniques to the development of compilers and operating systems. C.A.R. Hoare, the series' editor, states in the forward that the books are dedicated to elevating computer programming from a craft to a profession. Because structured programming methods lead to reliable and understandable programs, the topic is an integral part of the sequence.

The authors chose a programming language called Pascal Plus, a variant of Pascal, to illustrate the concepts they cover in the text. Several important extensions to standard Pascal make the language particularly useful in systems programming. For example, the language supports separate compilation through the use of a construct called an "envelope." Similar to the UCSD Pascal UNIT, an envelope lets you declare public and private constants, data structures, variables, and procedures and lets you initialize and terminate them. The language supports concurrent processes as well.

Structured Systems Programming is clearly and functionally organized. Using Pascal Plus as a vehicle, the authors instruct the reader in basic structuring techniques by dividing their presentation into three main parts. The first of these, appropriately enough, is an introduction to structured programming. Welsh and McKeag use the stepwise-refinement method to demonstrate program structuring. By making use of Pascal's excellent facilities for constructing new data types, the authors explain data structuring in a manner that is easy to understand.

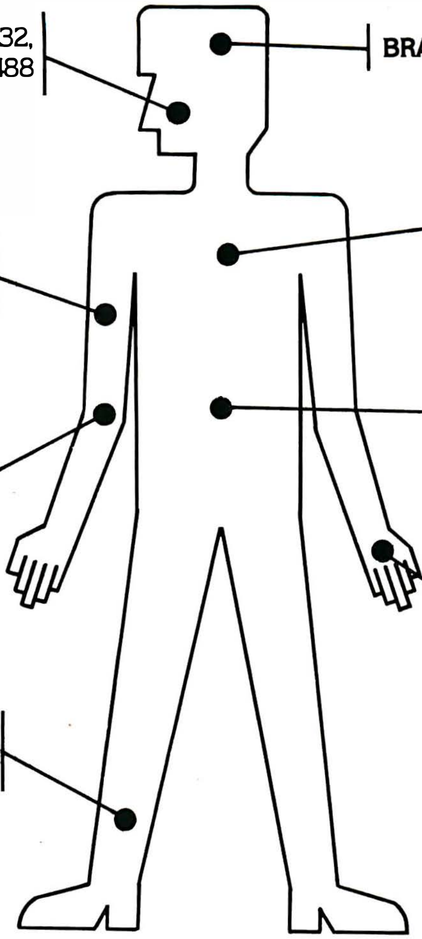
The block structuring method includes the use of procedures, envelopes, processes, and monitors. In Pascal Plus, a process is roughly equivalent to a procedure that can run concurrently with the main program and other processes. A monitor program enables several processes to have access to common buffers and procedures, but only one at a time. The need for such mutual exclusivity is obvious if you consider what might happen if one process is changing a piece of data while another process is using it. The monitor program provides a simple, structured method for avoiding chaos.

With the preliminaries taken care of, the second section of the book tackles an application: the construction of a structured compiler for a simple programming language. The authors were wise to illustrate the value of structured programming techniques by applying them to a nontrivial program that could otherwise become a quagmire of patches and afterthoughts.

The analysis of the problem

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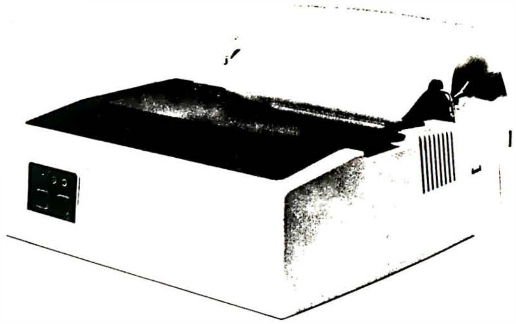
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begins with a precise specification of exactly how the completed program should operate. Next, the authors define Mini-Pascal, the language the model compiler translates. The authors analyze the problem in a logical order, treating source handling, lexical analysis, syntax analysis, semantic analysis, and code generation in sequence. In each of these sections, the authors specify the problem and break it down into its various parts. At the end of each section, you have a working piece of program that fulfills the objectives it was designed to meet. Almost before you know it, you have been lead through the development of a working compiler for a simple language that runs on a hypothetical machine.

The third and final section of the book details the programming methods you'll need to build a structured operating system. For two reasons, the operating system is more complicated than the compiler presented in the previous section. First, the operating system must be able to handle system resources concurrently. Second, the operating system has to interact more intimately with the hardware it runs on. Once again, the authors start with a program specification. The analysis proceeds with an examination of the resources that the operating system makes accessible to the user, including the main store, processor, and several peripherals such as card readers, line printers, typewriters, and the file store. As in the preceding section, the authors use stepwise refinement to divide each task into smaller and simpler pieces, then they devise a method to handle each of these smaller tasks. Pieces of the working operating system are listed at the end of each chapter.

The operating system is more complicated than the compiler because it must be able to handle system resources concurrently and it has to interact more intimately with its hardware.

The book has several strong points. It is both well written and well organized. The compiler and the operating system have been implemented successfully, which eliminates the subtle errors that often appear in books when the programs they detail have not actually been tested. In terms of its underlying philosophy the book resembles Niklaus Wirth's *Algorithms + Data Structures = Programs,* except that Welsh and McKeag's presentation is more geared to an experienced programmer. My main criticism is that the authors might have discussed concurrent programming more thoroughly, because it is a topic that will be new to many programmers.

The book's rather formidable price of $26 (apparently the going rate for books in the series) might deter some prospective readers, but its contents make it worth the money to anyone who is seriously interested in a clear introduction to systems programming.■

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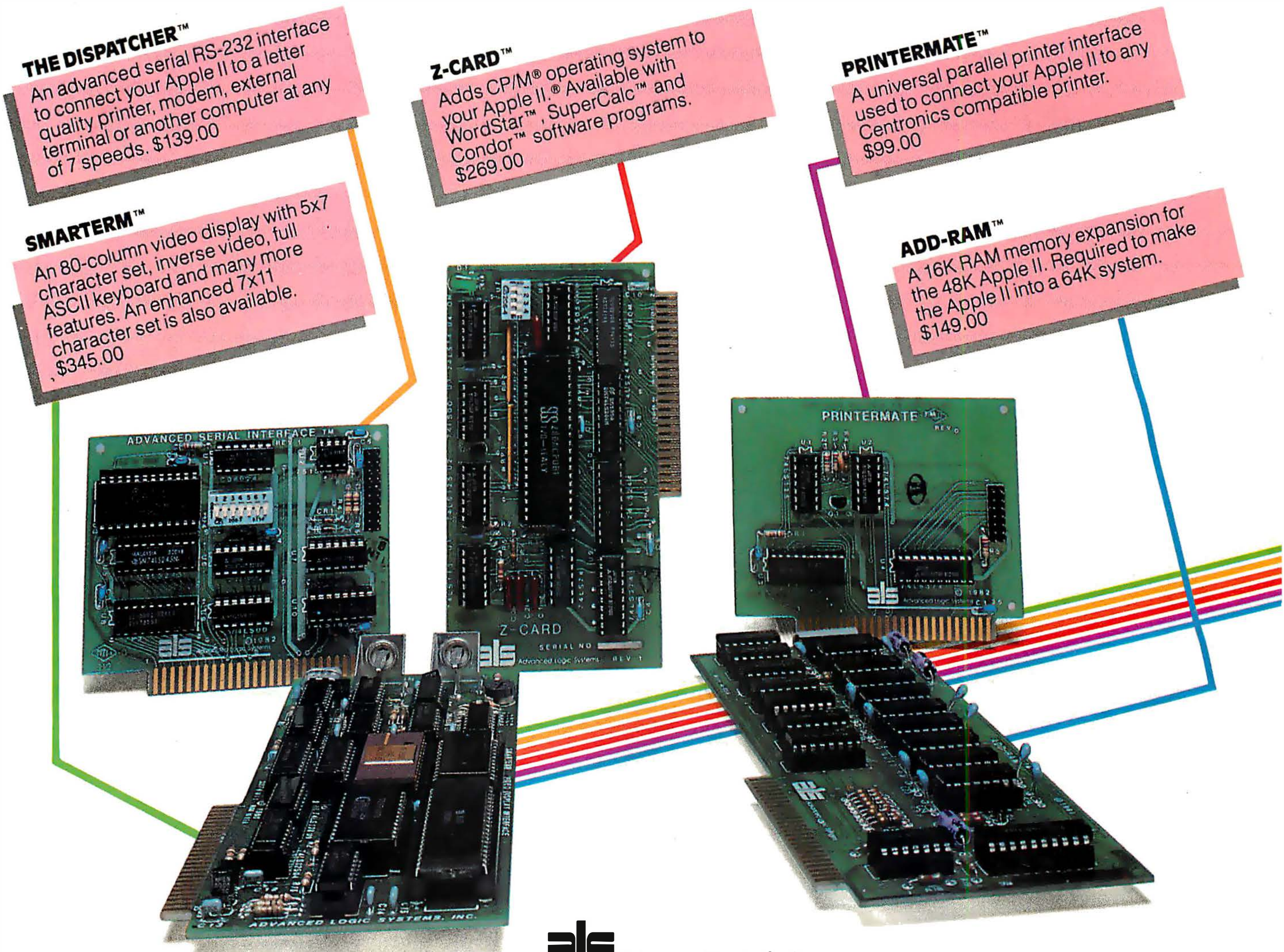
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Eratosthenes Revisited

Once More through the Sieve

A closer look at a benchmark prime-number program and various Pascal and C compilers.

Jim Gilbreath and Gary Gilbreath
7266 Courtney Dr.
San Diego, CA 92111

You can measure a computer system's performance in much the same way as you measure that of a racehorse: take out a stopwatch and measure how long it takes to go the distance. The "distance" for a computer, however, is often a set of benchmarks, programs that are designed to test the capabilities of a given system.

In a previous article in BYTE (see "A High-Level Language Benchmark," September 1981 BYTE, page 180) we proposed a simple benchmark program for microcomputers and used this program to compare a number of high-level languages on various computers. The particular program we used was a variant of the Sieve of Eratosthenes (pronounced Er-ah-TOS-the-neez), which finds all of the prime numbers between 3 and 16,381.

It is probably presumptuous to dignify this effort with the term "benchmark." A benchmark is usually very comprehensive and may require hours to run, even on a large mainframe computer. But the large volume of mail generated by our original article indicates that there is a significant interest in language testing and that many readers found the results to be useful as well as intriguing. In fact, several compiler writers indicated a rekindled interest in better code generation and have improved their products as a result. But the program is, at best, just one point on a very long curve and should be used as only one of many considerations in picking a language or a system.

In this article, we will take a closer look at this Sieve benchmark program, and we will pay particular attention to several Pascal and C compilers that have recently come onto the market.

Acknowledgments

Thanks are due to the many readers who contributed timing data and other comments. Special thanks are also due to the software houses that provided their latest versions for testing and help when problems arose.

About the Authors

Jim Gilbreath is the head of the Computer Sciences and Simulation Department at the Naval Ocean Systems Center. Gary Gilbreath is a third-year student of electrical engineering and computer science at University of California at San Diego and owner of his own software company.

The Program

A brief review of the program (listings 1 and 2 in Pascal and C, respectively) seems in order for the benefit of those who don't have ready access to the first article. The Sieve of Eratosthenes is a simple procedure for finding prime numbers, which was developed in the third century B.C. A prime number can be defined as a natural number that has two and only two distinct divisors (our thanks to James C. Fairfield for this definition). Thus 2 is the first prime, and all the rest are odd numbers. In the classic sieve procedure, you arrange all of the natural numbers in order and then cross out every second number after 2, every third number after 3, and so on, crossing out every nth number after n. The numbers that are not crossed out, which "pass through the sieve," are prime numbers.

Because all primes after 2 are odd, we start with the prime number 3 and "strike out" entries in an array of flags that represent odd numbers only. This array can now be only half as long as the largest prime we desire to calculate.

One feature of the program is that

Listing 1: *The Sieve of Eratosthenes prime-number program in Pascal.*

```
(* Eratosthenes Sieve Prime Number Program in Pascal *)
program prime;
const
  size = 8190;
var
  flags : array [0..size] of boolean;
  i,prime,k,count,iter : integer;
begin
  writeln('10 iterations');
  for iter := 1 to 10 do begin              {do program 10 times}
        count := 0;                         {prime counter}
        for i := 0 to size do
                flags[i] := true;           {set flags all true}
        for i := 0 to size do
                if flags[i] then begin      {found a prime}
                        prime := i+i+3;     {twice the index + 3}
                        {writeln(prime);}
                        k := i + prime;     {first multiple to kill}
                        while k <= size do begin
                                flags[k] := false; {zero a non-prime}
                                k := k + prime     {next multiple}
                        end;
                        count := count + 1  {primes found}
                end;
  end;
  writeln(count,' primes')                  {primes found in 10th pass}
end.
```

Listing 2: *The prime-number program in C.*

```
/* Eratosthenes Sieve Prime Number Program in C */
#define true 1
#define false 0
#define size 8190
    char flags[size + 1];
main() {
    int i,prime,k,count,iter;

    printf("10 iterations\n");
    for(iter = 1; iter <= 10; iter++) {         /*do program 10 times*/
        count=0;                                /*prime counter*/
        for(i = 0; i <= size; i++)              /*set all flags true*/
            flags[i] = true;
        for(i = 0; i <= size; i++) {
            if(flags[i]) {                      /*found a prime*/
                prime = i + i + 3;              /*twice index + 3*/
/*              printf("\n%d",prime);/*
                for(k=i+prime; k<=size; k+=prime)
                    flags[k] = false;           /*kill all multiples*/
                count++;                        /*primes found*/
            }
        }
    }
    printf("\n%d primes.",count);   /*primes foundon 10th pass*/
}
```

it avoids multiplication and division because these operations are usually slow, especially on microcomputers that do not have native instructions for these operations.

The first article listed several implementations of the Sieve program in various languages, but some of these listings contained errors. In the FORTH program, the word PRIME on line 11 should have been FLAGS. The FORTRAN program used array subscripts beginning with 0 (which is illegal for many compilers). And the COBOL program was not fully compliant with the ANSI (American Na-



Listing 3: *The prime-number program in FORTH.*

```
( Eratosthenes Sieve Prime Number Program in FORTH )
(This program does ONLY ONE iteration)
(Multiply times by 10 for comparison)

8190 CONSTANT SIZE
0 VARIABLE FLAGS    SIZE ALLOT

: DO-PRIME
  FLAGS SIZE 1 FILL    ( SET ARRAY )
  0 ( 0 COUNT )  SIZE  0
    DO  FLAGS I + C@
       IF I DUP + 3 + DUP I +
          BEGIN DUP SIZE <
          WHILE 0  OVER FLAGS +   C!  OVER + REPEAT
          DROP DROP 1+
       THEN
    LOOP
    .  ." PRIMES" ;
```

Listing 4: *The prime-number program in FORTRAN IV.*

```
C Sieve Program in "Structured" Fortran IV
        logical flags(8191)
        integer i,j,k,count,iter,prime

        write(1,100)
100     format(' 10 iterations')
        do 92 iter = 1,10
           count=0
           i=0
           do 10 i = 1,8191
10            flags(i) = .true.
           do 91 i = 1,8191
              if (.not. flags(i)) go to 91
              prime = i + i + 1
C             write(1,200) prime
200           format(1x,i6)
              count = count + 1
              k = i + prime
              if (k .gt. 8191) go to 91
              do 60 j = k, 8191, prime
60               flags(j) = .false.
91          continue
92      continue
        write(1,300) prime, count
300     format(1x,i6,' is the largest of ',i6, ' primes')
        end
```

Listing 5: *The prime-number program in BASIC.*

```
5 DEFINT A-Z
10 dim flags(8191)
20 print "10 iterations"
30 for m = 1 to 10
40      count = 0
50      for i = 0 to 8190
60              flags(i) = 1
70      next i
80      for i = 0 to 8190
90              if flags(i) = 0 goto 170
100                     prime = i + i + 3
105 REM                 print prime
110                     k = i + prime
120                     while k <= 8190
130                             flags(k) = 0
140                             k = k + prime
150                     wend
160                     count = count + 1
170     next i
180 next m
190 print count,"primes"
200 end
```

tional Standards Institute) 74 standard. Improved versions of these programs are given in listings 3 through 6.

Three other languages, Ada, Modula-2, and APL, are less common in the microcomputer world but are significant, especially Ada for the future. For the benefit of those who have access to compilers for Ada, Modula-2, and APL, we have included versions of the Sieve program, as contributed by readers, in listings 7 through 9.

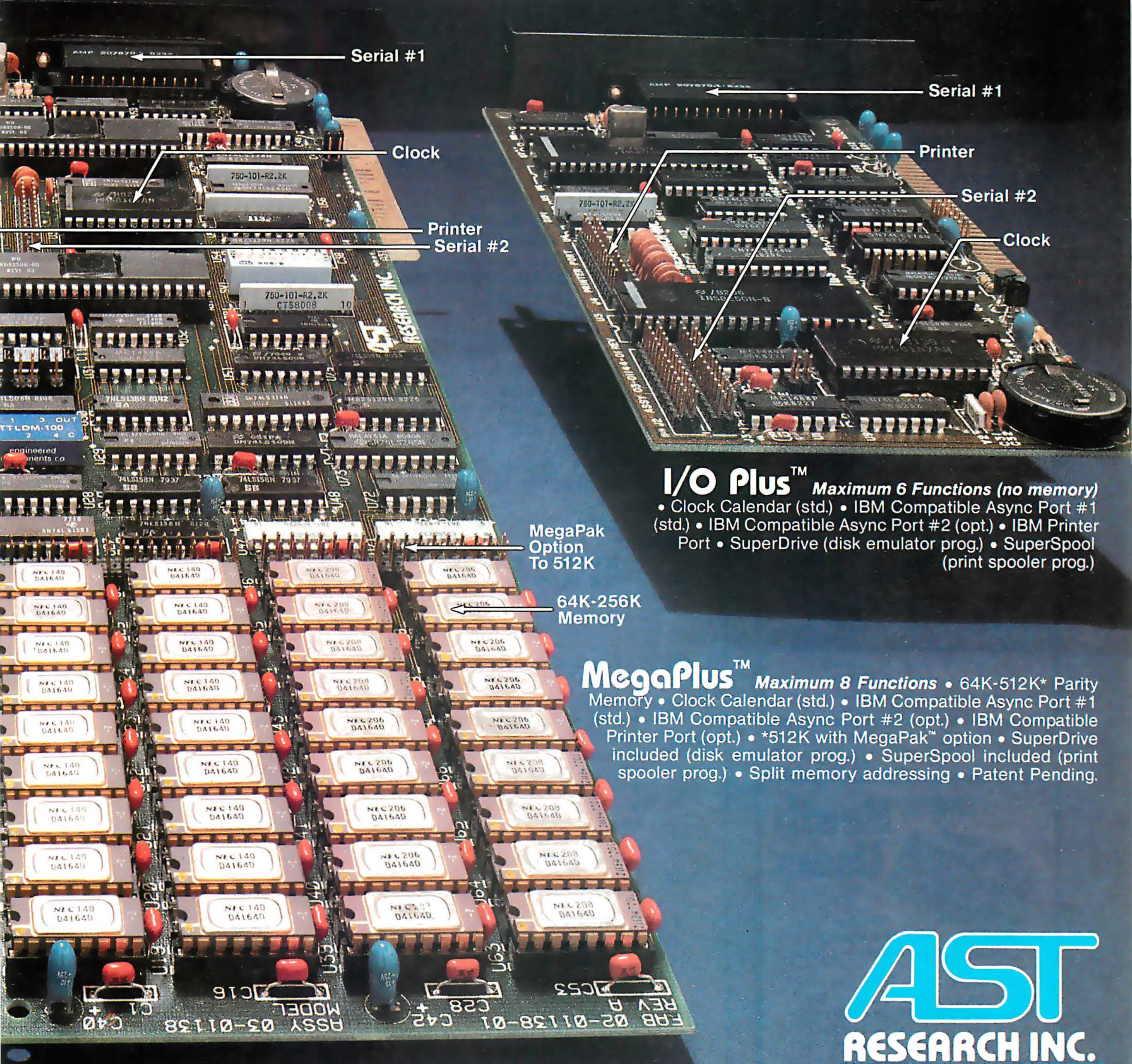
The ratio of speed between the fastest and slowest execution times was more than 700,000 to 1.

As you can see, in each version of the program there is a comment line to print out each prime when found. You can change this line to an actual program line and use it as a debugging aid, but it should be changed back to a comment for the actual timing tests.

Thanks to BYTE's Readers

In response to our original article, many readers have contributed timing results for several additional languages and computers that were not included in that article. We did not verify these results, but they are summarized in tables 1 and 2. Table 1 (on pp. 292-300) is a list of all the results sorted by computer, while table 2 (on page 303) is a comparison of the 10 fastest and slowest systems that were tested. Please note that all of the execution times in both tables have been adjusted for an array size of 8191 and a total of 10 iterations. We had to run the algorithm through some of the fastest computers thousands of times to get an accurate timing, whereas some of the slower languages could be accurately timed in only one iteration. As in the original article, execution time is defined as the time on a stopwatch between the beginning of the algorithm (signified by the appearance of the words "10 iterations" on the display screen) and the end of the program (when the screen dis-

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Listing 6: *The prime-number program in COBOL.*

```
* Eratosthenes Sieve Prime Number Program in COBOL
  IDENTIFICATION DIVISION.
  PROGRAM-ID.  PRIME.
  ENVIRONMENT DIVISION.
  CONFIGURATION SECTION.
  DATA DIVISION.
  WORKING-STORAGE SECTION.
  01 MISC.
          03 I               PIC 9(4)  COMP.
          03 K               PIC 9(5)  COMP.
          03 TOTAL-PRIME-COUNT PIC 9(4) COMP.
          03 PRIME           PIC 9(5)  COMP.
  01      FLAG-AREA.
          04 FLAGS           PIC 9 COMP OCCURS 8191 TIMES.
  PROCEDURE DIVISION.
  P.      DISPLAY ' 10 iterations'.
          PERFORM ITER-ROUTINE 10 TIMES.
          DISPLAY TOTAL-PRIME-COUNT ' primes'.
          STOP RUN.
  ITER-ROUTINE.
          MOVE ZERO TO TOTAL-PRIME-COUNT.
       PERFORM TABLE-FILLER-ROUTINE VARYING I FROM 1 BY 1
             UNTIL I > 8191.
       PERFORM DETAIL-COMPARE THRU D-C-EXIT VARYING I FROM 1 BY 1
          UNTIL I > 8191.
  TABLE-FILLER-ROUTINE.
          MOVE 1 TO FLAGS (I).
  DETAIL-COMPARE.
          IF FLAGS (I) = 0 GO TO D-C-EXIT.
          COMPUTE PRIME = I + I + 1.
          COMPUTE K = I + PRIME.
          PERFORM STRIKOUT
             UNTIL K > 8191.
          ADD 1 TO TOTAL-PRIME-COUNT.
*         DISPLAY 'FOUND PRIME = ' PRIME.
  D-C-EXIT.
          EXIT.
  STRIKOUT.
          MOVE 0 TO FLAGS (K).
          ADD PRIME TO K.
```

Listing 7: *The prime-number program in Ada.*

```
-- Erathosthenes Sieve Prime Number Generator Program in Ada
        PRAGMA Rangecheck IS(off);                 -- Faster execution
PACKAGE BODY Sieve IS
        Size : CONSTANT := 8190;                   -- Largest index
        Flags : ARRAY (0..Size) OF BYTE;           -- Array of flags
        Y : BYTE := BYTE(1);
        N : BYTE := BYTE(0);
        Count : INTEGER;                           -- Number of primes found
        K : INTEGER;                               -- Index into flag array
        Prime : INTEGER;                           -- Prime number
BEGIN
        PUT("10 Iterations");                      -- Type starting message
        NEW_LINE;                                  -- Output end of line
        FOR Iter IN 1..10 LOOP                     -- Do whole thing ten times
            Count := 0;                            -- No primes yet
            FOR I IN 0 .. Size LOOP                -- Set array of flags to
                Flags(I) := Y;                     -- TRUE (Y)
            END LOOP;
            FOR I IN 0 .. Size LOOP                -- Go through whole array
                IF Flags(I) = Y THEN               -- We have a prime
                    Prime := I+I+3;                -- Value of prime
                    K := I+Prime;                  -- Index to multiple
                    WHILE K<=Size LOOP             -- Loop to kill multiples
                        Flags(K) := N;             -- Set non-primes to FALSE (N)
                        K := K+Prime;              -- Next non-prime
                    END LOOP;                      -- End of kill multiples loop
--                  PUT(Prime);                    -- Display prime
--                  NEW_LINE;                      -- Output end of line
                    Count := Count+1;              -- Up count of primes
```

Listing 7 continued on page 290

Listing 7 continued:

```
            END IF;                        -- End of found primes
         END LOOP;                         -- End of loop through array
      END LOOP;                            -- End of iteration loop
      PUT(Count);                          -- Output number of primes
      PUT(" primes ");                     -- found
END Sieve;
```

Listing 8: *The prime-number program in Modula-2.*

```
(*Eratosthenes Sieve Prime Number Program in MODULA-2 *)
(* Info = Gunter Dotzel, Institut  fur Informatik *)
(* ETH-Zentrum CH-B092 Zuerich *)
MODULE Prime (* $T-,$S- *)
FROM INOut IMPORT Writeln, WriteInt, WriteString;
CONST Size=8190
VAR    Flags: ARRAY[0..Size] OF BOOLEAN;
       i,prime,k,count,iter: CARDINAL;
BEGIN
   Writeln; WriteString("10 iterations");
   FOR iter:=1 TO 100 DO
      count:=0;
      FOR i:=0 TO Size DO FLags[i]:=TRUE
      END;
      FOR i:=0 TO Size DO
         IF Flags[i] THEN
            prime:=i*2+3;
            k:=i+prime;
            WHILE k <= Size DO
               Flags[k]:=FALSE;
               INC(k,prime);
            END;
            INC(count);
         END;
      END;
    END;
    Writeln; Writeint(count,6); WriteString(´ primes´);
END Prime.
```

Listing 9: *The prime-number program in APL. Because our machinery cannot handle some of the APL characters, Alpa K. Kehta of Telecompute Integrated Systems Inc. has kindly sent us this listing.*

```
      ∇ PRIME N
[1] B←I←1⍝PTR←Nρ0
[2] L1:→(N<B×B←PR[I←I+1])/END⍝PR←(~PTR)/⍳N
[3] ST:→L1⍝PTR←PTR∨(Bρ0),B↓Nρ1⌽B↑1
[4] END:6 30ρPR,180ρ0
[5] ∇
```

plays "1899 primes"). Information regarding compile time, the amount of code generated, and the amount of memory used is not shown because it was usually not provided by the contributors. It is interesting to note that the ratio of speed between the fastest and slowest is more than 700,000 to 1.

Later Versions of the Compilers

Because we gathered most of the data for the first article somewhat informally, many significant products were not tested. When we first presented our results at a local computer society meeting prior to submitting them to BYTE, we used whatever languages were accessible in computer stores or available from members of the San Diego Computer Society. Many of the latest and greatest versions were not available for testing, which disappointed some software developers who felt they were compared unfairly with a competitor's later work. Unfortunately, this problem will always be present to some extent because this field is continually blossoming with new implementations.

For this article we decided to concentrate on the Pascal and C programming languages because of two recent events that have made these languages particularly noteworthy: the advent of a $29.95 Pascal compiler from JRT Systems, and Ron Cain's generous gift to the world of the source code for a small C compiler. This gift has spawned a number of low-cost and very useful versions of C, which are rapidly being implemented in just about every hardware environment.

The 8-bit Pascal and C compilers were tested on a 4-MHz Z80 system with 8-inch double-density floppy-disk drives.

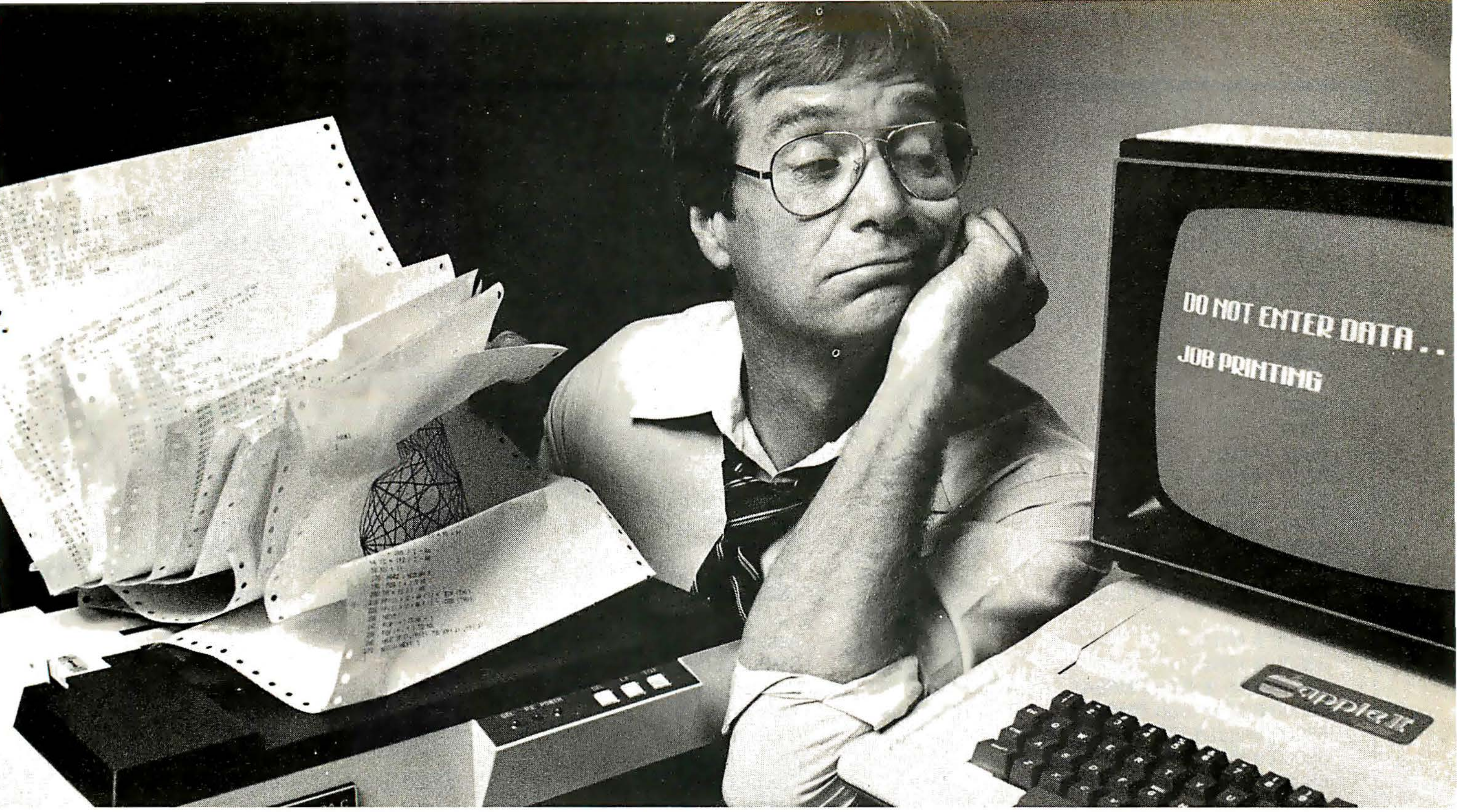
To be sure that a comparison of these products would be reasonably current, BYTE's editors helped in obtaining the latest versions of 6 Pascal compilers and 10 C compilers for the 8080/Z80 and 8086 microprocessors.

We tested the 8-bit Pascal and C compilers using a 4-MHz Z80 system with 8-inch double-density floppy-disk drives. The few 16-bit compilers available were tested on an 8-MHz 8086 system with the same disk drives. Compiler options for increased speed, such as turning off array-bounds-checking and code-debugging capabilities, and so on, were used as available. The Pascal program was changed a bit from the original version (see 1981 BYTE article) to eliminate the use of the FILLCHAR keyword because not all Pascal systems support it. It was replaced by a simple FOR loop, which may be a few percent slower but, at least, is the same for all. The results of these compilers on the prime-number program are given in table 3 (on page 303).

Improving the Execution Speed

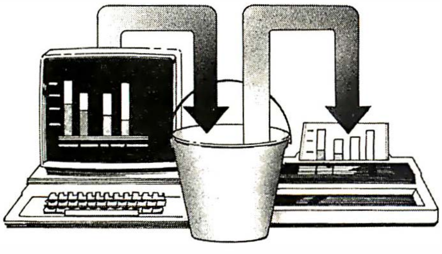
Some compilers (most of the C

Text continued on page 300



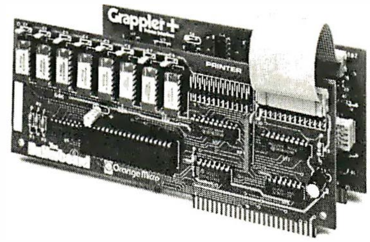
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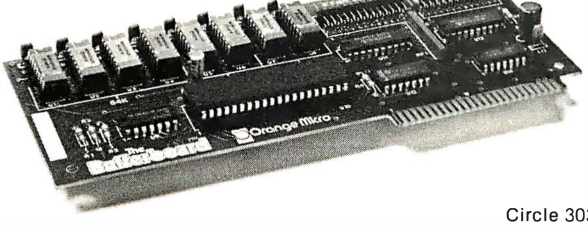
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Computer	Operating System	Language	Time (seconds)	Contributor
6502 OSI Superboard		Assembly	13.9	Paul Von Huben
6502 1 MHz OSI		XPLO	245	Don Box
6502		FORTH	265	BYTE, Sept. 1981
6502 1 MHz		RPL (Samurai Software)	265	Timothy Stryker
6502 1 MHz		FORTH (Figforth)	287	Timothy Stryker
6809		Assembly	5.1	Douglas K. Beck
6809		Lucidata Pascal	735	Douglas K. Beck
6809		TSC XBASIC	965	Douglas K. Beck
6809		C'ware BASIC	4303	BYTE, Sept. 1981
6809 1 MHz	MDOS	Omegasoft Pascal	40	Robert Reimiller
6809 1 MHz		Figforth	89	Raymond Mannarelli
6809 2 MHz		IMS Pascal native	8.78	Steve Keller
6809 2 MHz		IMS Pascal p	105	Steve Keller
6809 2 kHz	Flex	C (Introl)	11.0	John Wisialowski
6809 2 kHz		Figforth	45	Raymond Mannarelli
6809 2 MHz Gimix Ghost		TSC XBASIC	700	Conrad Swartz
68000 8 MHz		Assembly	0.49	Andrew Wood
68000 8 MHz		SMPL (Ebnek)	2.6	Steve Keller
68000 8 MHz (Sun PM68K)	ROS	Pascal (Telesoft)	4.28	Craig Maudlin
68000 8 MHz (Sun PM68K)	ROS	Ada (Telesoft)	4.4	Craig Maudlin
68000 Wicat 150WS	MCS/Unix	C (Johnson)	4.71	Authors
68000 8 MHz (HP-9830)	ROS	Ada (Telesoft)	5.0	Craig Maudlin
68000 8 MHz (HP-9830)	ROS	Pascal (Telesoft)	5.0	Craig Maudlin
68000 8 MHz	UCSD	Pascal (Softech native)	5.0	Softech
68000 8 MHz		Pascal (IMS Inc.)	5.8	Steve Keller
68000 8 MHz (HP-9830)	Pascal 1.0	Pascal (Hewlett-Packard)	5.9	Craig Maudlin
68000 Charles River 68	UNOS	C	6.3	Authors
68000 Wicat 150		Pascal	6.5	Richard Lane
68000 (4 MHz)		Pascal (Pascal MT)	9.00	BYTE, Sept. 1981
68000 8 MHz Exormacs		C (Whitesmiths)	9.82	Douglas K. Beck
68000 (4 MHz)		Pascal (Telesoft)	10.2	BYTE, Sept. 1981
68000 8 MHz Exormacs		Pascal (Motorola 1.2)	11.2	Douglas K. Beck
68000 8 MHz	MSP68000	FORTH (Hemenway)	27	Walt Patstone
8080 (MDS 8080)	ISIS	PL/M (Intel)	48.0	BYTE, Sept. 1981
8080		Dada	49	Dannie E. Davis
8080 (MDS 8080)		FORTH (JKL)	440	BYTE, Sept. 1981
8086 8 MHz		Assembly	1.90	BYTE, Sept. 1981
8086 8 MHz	CP/M-86	C (Digital Research V1.0)	2.8	Digital Research
8086 8 MHz	CP/M-86	Pascal (Digital Research MT+86)	4.76	Steve Clamage
8086 (Altos)	Xenix Unix	C (Microsoft)	6.0	Authors
8086 8 MHz	CP/M-86	C (Computer Innovations)	7.2	Authors
8086 8 MHz	MS-DOS	C (Computer Innovations)	7.2	Authors
8086 SBC 86/12 5 MHz		PL/M 86	8.8	Fred Dunlap
8086 5 MHz		Pascal (Intel Pascal-86)	9.05	BYTE, Sept. 1981
8086	UCSD	Pascal (Softech native)	17	John Tennant
8086 SBC 86/12 5 MHz		FORTH (Figforth 8086)	64	Fred Dunalp
8088 5 MHz		Assembly	4.0	Raymond Mannarelli*
8088 5 MHz	UCSD	Pascal (Softech native)	19.4	John Tennant
8088 5 MHz		FORTH (Laboratory Microsystems)	55	Ray Duncan
Apple II		Pascal (Apple Pascal)	160	Daniel Moroz
Apple II		FORTH (Fullforth)	190	Raymond Mannarelli
Apple II		FORTH (Cap'n Software)	198	Raymond Mannarelli
Apple II		FORTH (Figforth 1.0)	208	Guido Bettiol
Apple II		BASIC (On-line expediter)	213	James D. Childress
Apple II		Pascal (Mill-enhanced)	273	Raymond Mannarelli
Apple II		Sweet 16	292	Raymond Mannarelli
Apple II		FORTRAN (Mill-enhanced)	333	Raymond Mannarelli

Table 1: *Execution times of the Sieve of Eratosthenes prime-number program as run on various computers, operating systems, and programming languages. The results are listed alphabetically or numerically according to computer name. The results were either taken from the original BYTE article (September 1981, page 180), contributed by readers, or determined by the authors. We did not verify the results from contributors but simply printed them as we received them. That is why the number of significant digits varies. An asterisk (*) indicates a result that confirms a time listed in the original article. Execution time of the Sieve program, of course, should be regarded as only one of several considerations in choosing a particular language, system, or processor.*

Table 1 continued on page 294

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Table 1 continued:

Computer	Operating System	Language	Time (seconds)	Contributor
Apple II		Pascal (Apple)	390	Raymond Mannarelli
Apple II		FORTRAN (Apple)	509	Raymond Mannarelli
Apple II		UCSD Pascal	516	Raymond Mannarelli
Apple II		FORTH (Insoft Transforth)	1080	Charles Wells
Apple II		FORTH (Transforth)	1150	Guido Bettiol
Apple II		BASIC (Apple integer)	1850	BYTE, Sept. 1981
Apple III		BASIC	1860	R.W. Shore
Apple II		BASIC (Applesoft)	2806	Raymond Mannarelli
Atari 800		Pascal (Atari)	190	Raymond Mannarelli*
CDC Cyber 760		FORTRAN	0.723	Kerry Chesbro
CDC Cyber 170 Model 720		BASIC	9.5	Terry J. Deveau
Cray-1		FORTRAN	0.110	Kerry Chesbro
DEC-20		BASIC	7.7	Peter Fallon
H-6000		FORTRAN	2.06	Clark A. Calkins
Harris/6		Assembly	2.39	Peter M.B. Shames
Harris/6		FORTRAN 77	3.66	Peter M.B. Shames
Harris/6		C	4.89	Peter M.B. Shames
Honeywell 6080		FORTRAN	0.80	Richard Lane
HP-85		Assembly	21	Ronald B. Johnson
HP-85		BASIC	3084	Ronald B. Johnson
HP-1000F		Assembly	3.5	Rick Perins
HP-1000F		FORTRAN 77	4.6	Rick Perins
HP-1000F		FORTRAN IV X	5.3	Rick Perins
HP-1000F		Pascal 1000	5.8	Rick Perins
HP-1000F		C	6.6	Rick Perins
HP-1000F		Algol	23.2	Rick Perins
HP-3000		FORTRAN	10.0	BYTE, Sept. 1981
HP-3000		RATFOR	10.0	BYTE, Sept. 1981
HP-3000		Pascal	20.0	BYTE, Sept. 1981
HP-3000		COBOL	58.0	BYTE, Sept. 1981
HP-3000		BASIC	60.00	BYTE, Sept. 1981
H-89		UCSD Pascal	450	Desmond J. Charron
H-89		BASIC	4100	Desmond J. Charron
IBM 3033		Assembly	0.0078	Andrew Wood
IBM 3033		PL/I	0.036	James Gerber
IBM 3033		COBOL	0.0824	James C. Fairfield
IBM 3081		PL/I	0.034	James Gerber
IBM 4341	CMS	PL/I	0.135	James Gerber
IBM 3033 AP		FORTRAN H	0.258	Richard Franke
IBM 3033	CMS	FORTRAN	2.1	Richard Lane
IBM Series 1 4955	EDX	COBOL	38.7	A. Ross Stewart
IBM PC	DOS	C (Computer Innovations)	22.1	Authors
IBM PC	CP/M-86	C (Computer Innovations)	22.1	Authors
IBM PC	DOS	FORTH	70	Raymond Mannarelli
IBM PC	DOS	BASIC (Integer)	1950	Raymond Mannarelli
IBM PC	DOS	BASIC (Integer BASICA)	1990	Raymond Mannarelli
IBM PC	DOS	BASIC (Floating BASICA)	2400	Raymond Mannarelli
LSI-11/23	Xenix Unix	C (register variables)	4.0	John Wilson
LSI-11/23	Xenix Unix	C	9.3	John Wilson
LSI-11/23	Xenix Unix	RATFOR	11.4	John Wilson
LSI-11 Heath H-11		UCSD Pascal	221	George Schreyer
LSI-11 Heath H-11		UCSD FORTRAN	281	George Schreyer
LSI-11 (Terak)		UCSD Pascal	317	BYTE, Sept. 1981
Microengine		UCSD Pascal	63.0	BYTE, Sept. 1981
Modcomp Classic 7835		FORTRAN	4.56	Bob Van Cleef
Modcomp II/26		FORTRAN	7.5	Brad Boyce
Northstar Z80		N*BASIC	1580	Warren Lambert
NOVA 3		Assembly	4.2	Anne Anderson
NOVA 4		Assembly	3.1	Anne Anderson
Pascal 100	UCSD	UCSD Pascal	54.0	BYTE, Sept. 1981
PDP-11/03		UCSD Pascal	128	Daniel Moroz
PDP-11/15		FORTRAN	63	Clark A. Calkins

Table 1 continued on page 298

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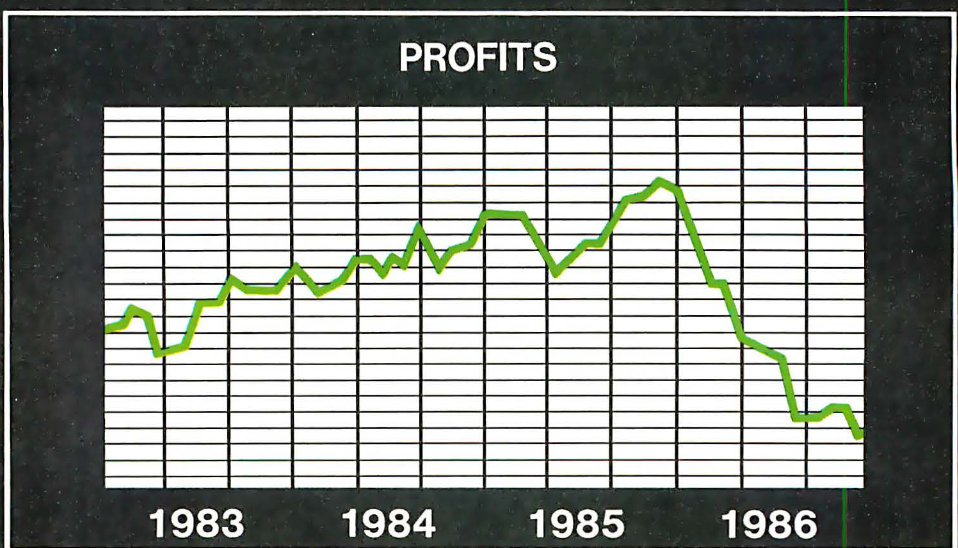
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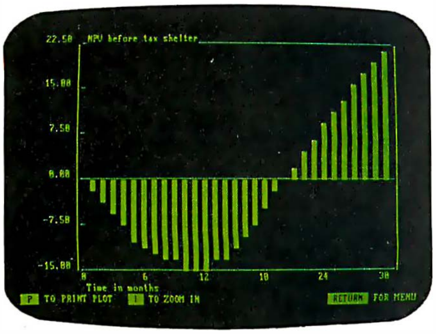
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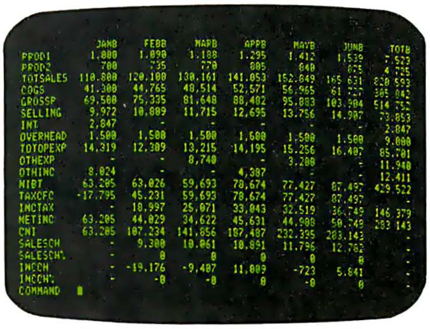
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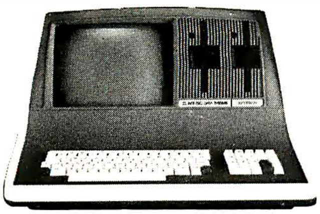
Table 1 continued:

Computer	Operating System	Language	Time (seconds)	Contributor
PDP-11/23		OMSI Pascal	4.8	Daniel Moroz
PDP-11/23		NBS Pascal	7.5	Gunter Dotzel
PDP-11/23		Modula-2	8.8	Gunter Dotzel
PDP-11/23		UCSD Pascal	40	Daniel Moroz
PDP-11/34		FORTRAN	30	Matti Kataja
PDP-11/40	Unix	C (Unix, 6)	6.10	BYTE, Sept. 1981
PDP-11/60	Unix	NBS Pascal	4.50	BYTE, Sept. 1981
PDP-11/70	Unix	C (Unix, 6)	1.52	BYTE, Sept. 1981
PDP-11/70	Unix	NBS Pascal	2.60	BYTE, Sept. 1981
PDP-11/70		BASIC Plus	8.1	Sam Malenfant
PDP-11/70	Unix	DECUS FORTH	11.8	BYTE, Sept. 1981
PDP-11/70	Unix	FORTRAN	15.8	H.P. Smith
PERQ-1	POS	Microcode	0.239	Gary Bickford
PERQ-1	Unix	C	5.8	Gary Bickford
PERQ-1	POS	Pascal	8.5	Gary Bickford
PERQ-1	POS	FORTRAN 77	15.1	Gary Bickford
PET		BASIC (PET)	3180	Raymond Mannarelli
Prime 300	Primos	FORTRAN	0.78	Richard L. Maurer
Prime 300	Primos	TIL FORTH	10.4	Richard L. Maurer
Prime 300	Primos	COBOL	50.4	Richard L. Maurer
Prime 300	Primos	BASIC	670	Richard L. Maurer
Prime 550		FORTRAN	2.13	John L. Homer
Prime 750	Primos	FORTRAN	1.4	Richard Lane
Prime 750	Primos	PL/I	2.5	Richard Lane
Superset PGM		FORTRAN (Superset)	12.0	BYTE, Sept. 1981
SWTPC 6809 1 MHz	OS-9	BASIC 09	410	Slim Cummings
SWTPC 6809 1 MHz	Flex	TSC XBASIC	1320	Slim Cummings
SWPTC 6809 2 kHz	Uniflex	TSC Pascal	34	Slim Cummings
SWTPC 6809 2 MHz	Flex	TSC Pascal	54	Slim Cummings
SWTPC 6809 2 MHz	OS-9	BASIC 09	238	Slim Cummings
SWTPC 6809 2 MHz	Flex	Dynasoft Pascal	309	Slim Cummings
SWTPC 6809 2 MHz	Uniflex	TSC XBASIC	810	Slim Cummings
SWTPC 6809 2 MHz	Flex	TSC XBASIC	840	Slim Cummings
TI 99/4		BASIC (TI-BASIC)	3960	Victor Dodier
TI 990/10		FORTH (Polyforth)	60.2	BYTE, Sept. 1981
TM 990/189		Assembly	14.8	Robert D. Hardy
TM-16 (bit slice)		Assembly	0.96	Glenn A. Toennes
TM-16 (bit slice)		FORTH	55	Glenn A. Toennes
TMS9900 3 MHz		Assembly	6.5	Peter Butterworth
TRS-80 Mod I		MMSFORTH 1.9	190	Raymond Mannarelli
TRS-80 Mod I		Miller FORTH	253	BYTE, Sept. 1981
TRS-80 Mod II		UCSD Pascal	274	Raymond Mannarelli
TRS-80 Mod II		BASIC	1430	John L. Homer
TRS-80 Mod II	TRSDOS	MBASIC	2250	Raymond Mannarelli*
TRS-80 Mod III		BASIC	2880	John L. Homer
TRS-80 Mod III	TRSDOS	Disk BASIC	4780	Matt Ewing
Univac 1100/82	OS 1100	FORTRAN 77	0.668	Tom Gruber
Univac 1100/83	OS 1100	FORTRAN V	0.76	Desmond J. Charron
Univac 1100/82	OS 1100	COBOL	1.42	Tom Gruber
Univac V77-600		POL (Taylor Instrument)	10.84	Patricia Farrell
VAX-11/780	Unix	C (UC Berkeley)	1.42	H. P. Smith
VAX-11/780	VMS 2.3	FORTRAN V2.3-53	1.45	Clark A. Calkins
VAX-11/780	VMS	FORTRAN (DEC)	1.55	Pete Ridley
VAX-11/780	VMS	C (DECUS)	2.3	Pete Ridley
VAX-11/780	VMS 2.3	Pascal T1.2-80	2.31	Clark A. Calkins
VAX-11/780	Unix	FORTRAN 77	2.34	H. P. Smith
VAX-11/780	VMS/ROS	Pascal (Telesoft)	4.94	Craig Maudlin
VAX-11/780	VMS/ROS	Ada (Telesoft)	5.6	Craig Maudlin
Xerox 820 Z80	CP/M	RMCOBOL	5740	J. Stevens Blanchard
Z80	CP/M	Assembly	6.8	Raymond Mannarelli
Z80	CP/M	Coral	13.8	John Wilson
Z80	CP/M	FORTRAN (Microsoft V3.2)	13.9	Authors
Z80	CP/M	PL/I (Digital Research)	14.0	BYTE, Sept. 1981
Z80	CP/M	C (BD Systems V1.46)	15.2	Leor Zolman

Table 1 continued on page 300

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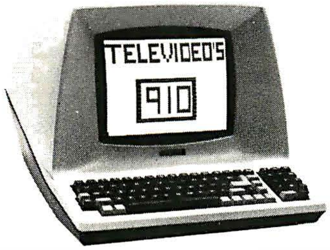
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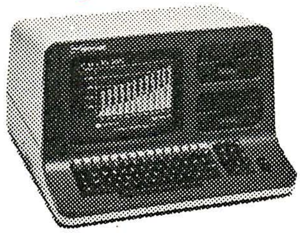
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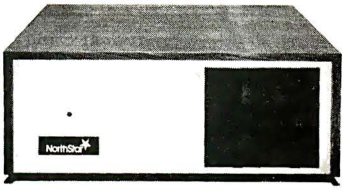
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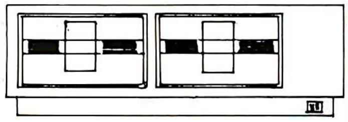
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Table 1 continued:

Computer	Operating System	Language	Time (seconds)	Contributor
Z80	CP/M	BASIC (Digital Research CB80)	15.7	Authors
Z80	CP/M	RATFOR (TSW)	16.5	BYTE, Sept. 1981
Z80	CP/M	FORTRAN (Microsoft)	17.0	BYTE, Sept. 1981
Z80	CP/M	BASIC (Microsoft BASCOM)	17.7	Authors
Z80	CP/M	ZSPL (V1.58)	18.0	Pete Ridley
Z80	CP/M	C (Interactive Systems ZC)	18.5	BYTE, Sept. 1981
Z80	CP/M	ZSPL V1.38	18.5	BYTE, Sept. 1981
Z80	CP/M	BASIC (Microsoft BASCOM)	18.6	BYTE, Sept. 1981
Z80	CP/M	Pascal (Pascal/MT+)	19.0	BYTE, Sept. 1981
Z80	UCSD	Pascal (Softech native)	19.7	John Tennant
Z80	CP/M	PLMX (Syscon)	22.5	BYTE, Sept. 1981
Z80	CP/M	Pascal (Pascal/MT+ V5.5)	22.7	Authors
Z80	CP/M	C (Software Toolworks 2.0)	25.4	Authors
Z80	CP/M	C (Whitesmiths 2.1)	25.5	Authors
Z80	CP/M	C (Whitesmiths 2.0)	25.7	Authors
Z80	CP/M	Ada (Janus 1.0)	27	Pete Ridley
Z80	CP/M	Pascal (Pascal/Z V4.0)	31.4	Authors
Z80	CP/M	C (Manx Aztec C 1.04)	32.9	Authors
Z80 Apple II Softcard	CP/M	FORTRAN (Microsoft Card)	34	Raymond Mannarelli
Z80	CP/M	C (Supersoft 1.1.0)	34.1	Authors
Z80	CP/M	C (BD Systems V1.0)	35.0	BYTE, Sept. 1981
Z80	CP/M	Ada (Janus 1.4.3)	36	Tom Lettington
Z80	CP/M	C (Telecon)	37.9	Authors
Z80	CP/M	C (BDS 1.46)	39.9	Authors
Z80 (Kaypro II 2.5 MHz)	CP/M	C (Software Toolworks 2.0)	40.6	Authors
Z80	CP/M	C (Q/C 1.10)	48.8	Authors
Z80	CP/M	C (BD Systems V1.32)	49.5	BYTE, Sept. 1981
Z80	CP/M	C (Infosoft 2.03)	50.8	Authors
Z80	UCSD	Pascal (Softech native)	51.2	Authors
Z80	CP/M	C (Code Works 1.0)	53.2	Authors
Z80	CP/M	Pascal (Whitesmiths)	63.0	Jay Allen
Z80		FORTH (Timin release 3)	75.9	Mitchell E. Timin
Z80		FORTH (Laboratory Microsystems)	78	Ray Duncan
Z80		FORTH (Figforth)	84	Jonathan Sachs
Z80	CP/M	Pascal (Pascal/Z V3.0)	109	BYTE, Sept. 1981
Z80		FORTH (JKL FORTH)	112	BYTE, Sept. 1981
Z80 2 MHz Sorcerer		FORTH (Laboratory Microsystems)	150	R.S. Neuman
Z80	UCSD	Pascal (Softech IV.03)	156	John Tennant
Z80	UCSD	UCSD Pascal	239	BYTE, Sept. 1981
Z80	CP/M	Pascal (JRT V2.0)	383	Authors
Z80 4 MHz	CP/M	Pascal (Pascal/M 4.02)	416	C. Clifton Smith
Z80	CP/M	Ada (Supersoft 1.20A)	422	Tom Lettington
Z80	CP/M	Pascal (Pascal M)	450	BYTE, Sept. 1981
Z80	CP/M	Pascal (JRT)	470	BYTE, Sept. 1981
Z80	CP/M	CBASIC2 (integer)	484	BYTE, Sept. 1981
Z80	CP/M	C (tiny-c 2 compiler)	930	BYTE, Sept. 1981
Z80	CP/M	CBASIC2 (real)	1430	BYTE, Sept. 1981
Z80	CP/M	MBASIC (Microsoft 5.2)	1476	Authors
Z80	CP/M	MBASIC (Microsoft)	1920	BYTE, Sept. 1981
Z80		APL (Telecompute)	3276	Alpa K. Mehta
Z80	CP/M	C (tiny-c)	4720	BYTE, Sept. 1981
Z80	CP/M	COBOL (Microsoft V2.2)	5115	BYTE, Sept. 1981
Z8000 Onyx	Unix	C (Onyx)	3.20	BYTE, Sept. 1981
Z8000 Zilog Systems 8000-20		C	4.06	Zilog Inc.
Z8000 Z-Lab	Zeus Unix	C	4.8	John Wilson
Z8000 (Zehntel SDM)	Xenix Unix	C (Microsoft)	6.0	Authors
Z8001, 5.5 MHz	Unix	Assembly	1.1	Lawrence A. Leske
Z8001, 5.5 MHz	Unix	C	1.97	Lawrence A Leske

compilers, for example) provide alternative data storage methods that can be optimized for some applications. Forcing variables to be register, static, or global instead of automatic (stack-dwelling) can, with some compilers, provide dramatic improvements in execution speed, though often at the expense of something else such as recursion ability or memory size. We experimented with these things on all the C compilers to see just how fast we could get each to run the program. The most dramatic improvement was obtained with the BD Systems compiler by moving all the data into the global area, thus effectively making the data static (i.e., keeping the data in memory rather than on a stack). Table 4 (on page 303) gives the results of the best speed we attained with each compiler, but there may be room for improvement. We probably didn't find all the secrets.

Text continued on page 306

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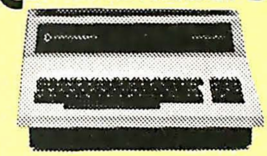
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IBM 3033		Assembly	0.0078	Andrew Wood
IBM 3081		PL/I	0.034	James Gerber
IBM 3033		PL/I	0.036	James Gerber
IBM 3033		COBOL	0.082	James C. Fairfield
Cray-1		FORTRAN	0.110	Kerry Chesbro
IBM 4341	CMS	PL/I	0.135	James Gerber
PERQ-1	POS	Microcode	0.239	Gary Bickford
IBM 3033 AP		FORTRAN H	0.258	Richard Franke
68000, 8 MHz		Assembly	0.49	Andrew Wood
Univac 1100/82	OS 1100	FORTRAN 77	0.67	Tom Gruber
HP-85		BASIC	3084	Ronald B. Johnson
PET		PET BASIC	3180	Raymond Mannarelli
Z80		APL	3276	Alpa K. Mehta
TI 99/4		TI-BASIC	3960	Victor Dodier
H-89 2 MHz		BASIC	4100	Desmond J. Charron
6809		BASIC	4303	BYTE, Sept. 1981
Z80	CP/M	C (tiny-c)	4720	BYTE, Sept. 1981
TRS-80 Mod III	TRSDOS	BASIC	4780	Matt Ewing
Z80	CP/M	COBOL Microsoft	5115	BYTE, Sept. 1981
Xerox 820	CP/M	RMCOBOL	5740	J. Stevens Blanchard

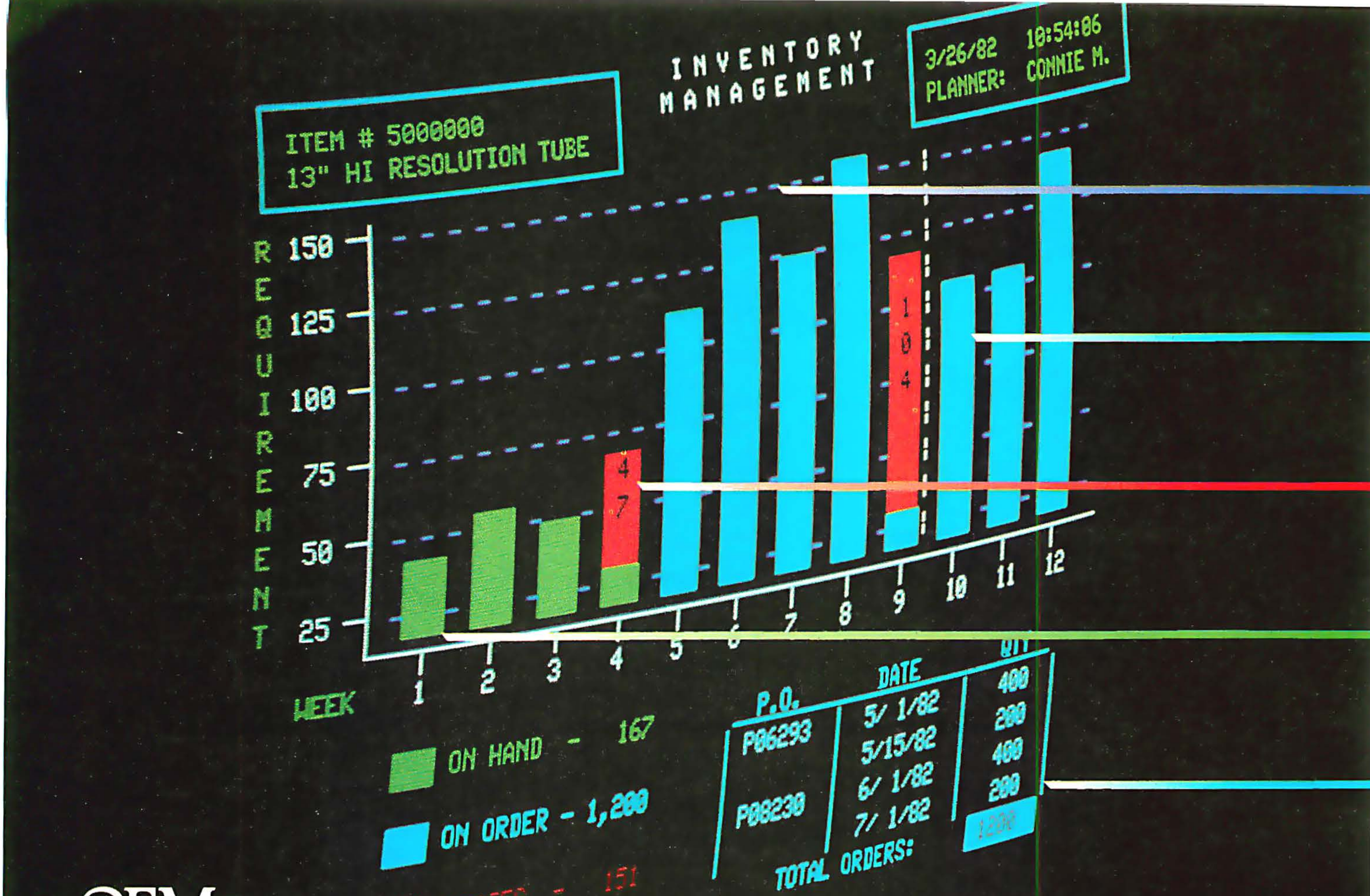
Table 2: *The ten fastest and slowest systems of those tested with the Sieve of Eratosthenes prime-number program as listed in table 1. Again, execution time of the Sieve program should be regarded as only one of several considerations in choosing a particular language, operating system, or processor.*

	Compiled Bytes	Memory Used (bytes)	Compile Plus Load (seconds)	Execution Time (seconds)
Pascal Compilers				
UCSD Pascal, Softech, IV.03 with Z80 Native-Code Generator	442	18,874	87.9	19.7
Pascal/MT+, Digital Research, V5.5	344	3816	50.8	22.7
Pascal/Z, Ithaca Intersystems, V4.0	687	3645	75.0	31.4
UCSD Pascal, Softech, IV.03	237	18,669	46.7	156
JRT Pascal, JRT Systems, V2.0	224	22,008	34.5	383
Pascal/MT+86, Digital Research (8-MHz 8086)	301	11,129	50.2	4.76
C Compilers				
C/80, Software Toolworks, V2.0	279	3106	37.2	25.4
C, Whitesmiths Ltd., V2.1	332	12,018	310	25.5
Aztec C, Manx Software, V1.04	355	8515	86.2	32.9
C, Supersoft Inc., V1.1.0	394	17,729	84.7	34.1
C, Telecon Systems	382	5751	201	37.9
BDS C, BD Software, V1.46	311	3701	20.7	39.9
(with -e and -o options)	354	3839	20.9	24.7
Q/C, Quality Computer Systems, V2.0b	361	3310	49	48.8
C, Infosoft Systems, V2.03	410	8655	96	50.8
CW/C, The Code Works, V1.0	399	1833	71	53.2
C86, Computer Innovations, V1.29B (8-MHz 8086)	250	4097	58	7.2

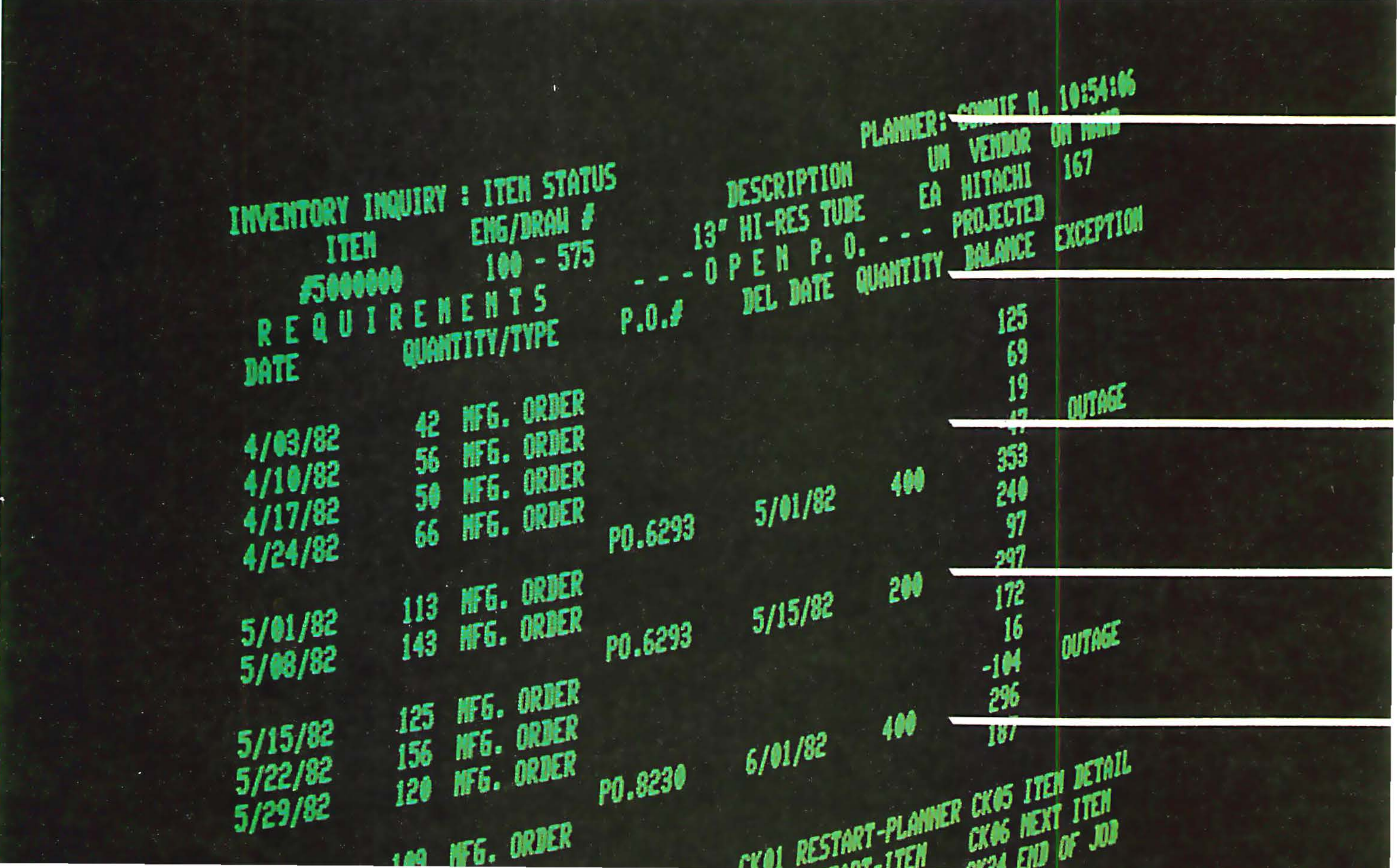
Table 3: *Performance of the Sieve of Eratosthenes prime-number program on several new Pascal and C compilers. Compilers are listed in order of execution speed. Memory used does not include the 8191-byte array but does include necessary library routines and p-code interpreters.*

	Compiled Bytes	Memory Used (bytes)	Compile Plus Load (seconds)	Execution Time (seconds)
C Compilers				
BDS C, BD Software, V1.46	240	3664	20.7	15.2
C, Whitesmiths Ltd., V2.1	227	11,913	310	15.9
Aztec C, Manx Software, V1.04	219	8379	86.2	20.5
C/80, Software Toolworks, V2.0	239	3066	37.2	25.5
Q/C, Quality Computer Systems, V2.0b	253	3208	49	26.1
C, Telecon Systems	253	5622	201	27.8
C, Infosoft Systems, V2.03	279	8524	96	27.9
CW/C, The Code Works, V1.0	301	1735	71	30.3
C, Supersoft Inc., V1.1.0	360	17,695	84.7	30.9
C86, Computer Innovations, V1.29B (8-MHz 8086)	250	4097	58	7.2

Table 4: *Performance of the Sieve of Eratosthenes prime-number program on various C compilers using optimized data allocation. As in table 3, compilers are listed in order of execution speed, and memory used does not include the 8191-byte array but does include the necessary library routines.*



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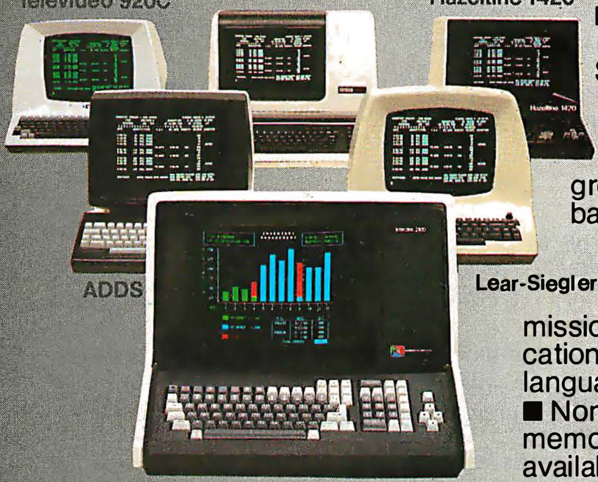
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Listing 10: *The improved prime-number program in C.*

```
/* Improved Sieve Program in C */
#define true 1
#define false 0
#define size 8190
#define maxi 127
   /* maxi is sqrt(2*size) */
char flags[size + 1];
int i,k,prime,count,iter,strikout;
main()
{
    printf("10 iterations\n");
    for(iter = 1; iter <= 10; iter ++) {
        strikout = true;
        count=0;
        for(i = 0; i <= size; i++) flags[i] = true;
        for(i = 0; i <= size; i++) {
            if(flags[i]) {
                prime = i + i + 3;
/*              printf(" %d",prime); */
                count ++;
                if(strikout) {
                    if(prime > maxi)
                        strikout = false;
                    else
                        for(k = i + prime; k <= size; k += prime)
                        flags[k] = false;
                }
            }
        }
    }
    printf("\n%d is largest of %d primes.",prime,count);
}
```

Listing 11: *A further improved Sieve program in C. This program saves time by blanking out multiples of primes starting at the square of the prime rather than at the prime times 3. Unlike the other programs, this program uses multiplication.*

```
/* A C version of the Sieve program as suggested by KNUTH */
/*   (uses a multiply, though) */
#define true 1
#define false 0
#define size 8190
char flags[size + 1];
int i,k,prime,count,iter,strikout;

main()
{
    printf("10 iterations\n");
    for(iter = 1; iter <= 10; iter ++) {
        strikout = true;
        count=0;
        for(i = 0; i <= size; i++) flags[i] = true;
        for(i = 1; i <= size; i++) {
            if(flags[i]) {
                prime = i + i + 1;
/*              printf(" %d",prime); */
                count++;
                if(strikout) {
                    if((k = ((prime*prime)-1) >> 1) < size)
                        for(; k <= size; k += prime)
                            flags[k] = false;
                    else {
                        strikout = false;
                        continue;
                    }
                }
            }
        }
    }
    printf("\n%d is largest of %d primes.",prime,count);
}
```

A Better Algorithm

Two readers, Charles Marcus and Dwight Divine III, have pointed out to us that the algorithm used in the first article can be improved a bit. By the time the program has looped 63 times (producing the prime number 127) all of the nonprime numbers less than 16,381 will have been flagged at least once, and the remaining loops will redundantly flag nonprimes yet again. Listing 10 gives a program in C that avoids this problem by setting a flag after reaching 127 so that nonprime flagging is not done after this time. It runs about 26 percent faster for an array size of 8191 and would be even faster with larger arrays.

Can we do better yet? Definitely! Marcus also noted that although Eratosthenes was recognized by his contemporaries as a man of great distinction in all branches of knowledge, in each subject he fell just short of the highest place. And so it is that Professor Donald E. Knuth suggests to his students in an exercise in volume two of *The Art of Computer Programming* (see references) that the blanking of nonprimes begin with the square of the prime rather than prime times 3. The C program in listing 11 provides this optimization but uses multiplication. This algorithm runs in 15.2 seconds in BDS C. A similar program in Microsoft FORTRAN requires 11.9 seconds. It can also be done without multiplication, as shown in a program (in FORTRAN) contributed by Mr. Marcus (listing 12). This algorithm runs in 12.9 seconds in both BDS C and Microsoft FORTRAN.

Can we improve it further? Marcus points out that a great deal of work has been done in devising linear algorithms for the sieve problem whereby each nonprime is removed only once. If this can be done without multiplication, significant improvement in execution time could be achieved. If you find a way, let us know.

Machine Code versus P-Code

It should be noted that two of the Pascal compilers we concentrated on produce object code and two produce p-code (pseudocode), which is then interpreted, usually at a slower

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Listing 12: *An improved Sieve program in FORTRAN written by Charles Marcus. This program saves time by blanking out multiples of primes starting at the square of the prime and does not use multiplication.*

```
C Charles Marcus' Fortran version without multiplication
        integer size,prime,count
        logical flags(8191),last
        data size /8191/

        write(1,10)
10      format (' 100 iterations')
        do 20 iter = 1, 100
           count = 0
           do 30 i = 1, size
30            flags(i) = .true.
           k = 4
           last = .false.
           do 40 i = 1, size
                if (.not. flags(i)) go to 50
                   prime = i + i + 1
                   count = count + 1
C                  write(1,11) prime
11                 format (1x,i6)
                   if (last) go to 40
                      do 60 j = k, size, prime
60                       flags(j) = .false.
50                    if (last) go to 40
                      k = k + i + i + i + i + 4
                      if (k .gt. size) last = .true.
40              continue
20      continue
        write(1,12) count
12      format (1x, i6, ' primes')
        end
```

speed for this type of program. Both techniques have their place. P-code allows sophisticated features such as true dynamic storage, unrestricted recursion, and easier implementation on a variety of hardware but at the expense of speed for most problems. Softech Microsystems' Z80 Native Code Generator attempts a marriage of both methods. It processes a .CODE file from the p-code compiler, producing a second .CODE file that contains Z80 machine code wherever feasible. It increased the execution speed for the prime program by a factor of nearly eight if range checking was turned off.

Another Benchmark

Since the Eratosthenes Sieve program does a lot of looping and array subscripting and is thus biased strongly toward machine-code compilers, we decided to compare the Pascal and C compilers on another program that does a lot of file reading and writing and simple string processing. This second program is an elementary wire-list program, which we

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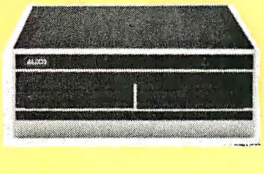
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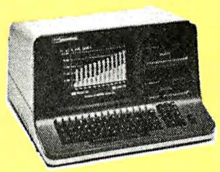
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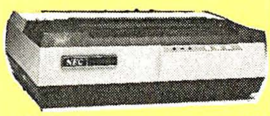
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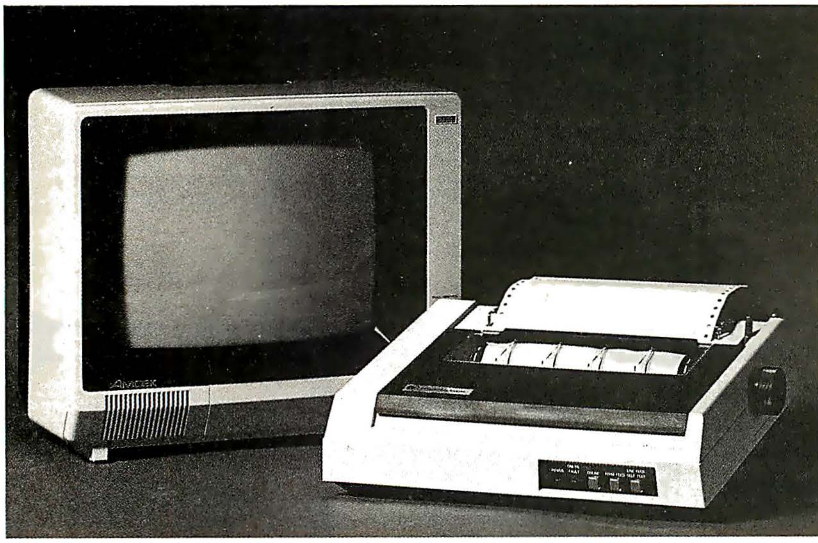
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originally presented in an article in *Microsystems* (Jan/Feb 1982, page 66), titled "Use Your Computer to Build a Computer."

The purpose of this program is to prepare a list of wires to connect the pins of the integrated circuit chips and components of a given circuit. To do this, the program takes as input a list of the pin numbers and corresponding signal names for each component of the circuit. The program's output, after it is sorted, is a list in which all of the pins with the same signal name are grouped together. This grouping makes it very easy for a technician to connect these pins, whether by wire-wrap or printed-circuit board.

Listings 13 and 14 present the program in Pascal and C. The input file used for the comparisons is the coded schematic for a Z80 processor board. (A copy of the input file is available from the authors on 8-inch CP/M disk for $5 in case you need it for comparisons with other languages or hardware.)

Performance of this program depends very much on the specific implementation of the run-time interface to the operating system. Buffer sizes and blocking procedure are strong influences, and so is any existing fragmentation of the file system. We ran each test on a "clean" disk so that seek-time differences would be minimal. Some changes from the listings had to be made for some of the compilers. Transporting the program to the different C environments was relatively easy. Implementing the Pascal program was considerably more difficult because of differences in string abilities and the widely differing file input/output (I/O) procedures. We have probably not taken best advantage of every language's I/O possibilities, and we did not attempt to write the Pascal program in adherence to "standard" Pascal, which has no strings, because all the compilers tested have some type of strings available. The results of our testing are given in table 5 (on page 323).

Opinions and Impressions

This article is not intended to be a

Text continued on page 320

Listing 13: *The wire-list program in Pascal.*

```
program wirelist;
{---------------------------------------------------------------------}
{ Program to process a CP/M file in the form:                         }
{                                                                     }
{  .SOCKET =ICTYPE                                                    }
{       PIN-NO SIGNAL, PIN-NO SIGNAL,                                 }
{       PIN-NO SIGNAL, ETC                                            }
{                                                                     }
{ The program asks the input file name.  It then asks for an output   }
{ base file name, and produces 3 output files, named BASE.ERR,        }
{ BASE.IC, and BASE.PAR, containing error messages, parts list, and   }
{ parsed signal-pin list, respectively. the .PAR file, when sorted    }
{ into alphabetical order, becomes a network list which is useful     }
{ for wire-wrap, PC layout, error checking, and documentation.        }
{---------------------------------------------------------------------}
var
  error : boolean;
  result : integer;
  inname,                       { file of input data }
  outname : string;             { base file name for output info }
  infile : text;                { where data comes from }
  errfile : text;               { where errors go }
  icfile : text;                { where parts list goes }
  parsefile : text;             { where parsed output goes }
  linenum : integer;            { keeps track of line numbers on input file }
  term : char;                  { what terminated each word }
  word : string;                { where getword puts the word it got }
  socket,                       { where socket name goes }
  ics,                          { string to save socket and ic type }
  pinname : string;             { so it is }

procedure initfiles;
var
  dummy : string;
begin
  write('Input file name? ');
  readln(inname);
  assign(infile,inname);
  reset(infile);
  writeln;
  write('Base name of output files: ');          { ask for output file }
  readln(outname);
  assign(errfile,concat(outname,'.ERR'));
  rewrite(errfile);
  assign(icfile,concat(outname,'.IC'));
  rewrite(icfile);
  assign(parsefile,concat(outname,'.PAR'));
  rewrite(parsefile);
end;
procedure check_for_eoln;
begin
  if eoln(infile) then
    linenum := linenum + 1;
end;

function start_of_word(c:char):boolean;
begin
  if (c = chr(13)) or (c = chr(9)) or (c = ' ') then
    start_of_word := false               { not start of word }
  else
    start_of_word := true;               { it is start of word }
end;

function end_of_word(c:char):boolean;
begin
  if (c = chr(13)) or (c = ' ') or (c = chr(9)) or (c = ',') then
    end_of_word := true                  { it is end of word }
  else
    end_of_word := false;                { not end of word }
end;

{ gets next word into global string word }
function getword:char;
var
  i : integer;
begin
  while (not start_of_word(infile^)) and (not eof(infile)) do
    begin
```

Listing 13 continued on page 314

S-100 Modular Products

All Modular Products CP/M 3•0 compatible.

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Listing 13 continued:

```
      check_for_eoln;
      get(infile);              { pass by spaces, tabs }
    end;
  if eof(infile) then
    getword := chr(0)           { return end-of-file }
  else
    begin
      i := 1;                   { assemble the word now }
      repeat
        word[i] := infile^;     { build string }
        i := i + 1;
        get(infile);
        check_for_eoln;
      until (end_of_word(infile^)) or (eof(infile));
      if eof(infile) then
        getword := chr(0)
      else if eoln(infile) then
        getword := chr(13)      { return c/r for end of line }
      else
        getword := infile^;     { else return termination character }
      get(infile);
      word[0] := chr(i-1);      { set string length }
    end;
end;

procedure process_pin;
begin
  if word[1] = '$' then         { ignore any word beginning with $ }
    term := getword;
  if term <> chr(0) then        { if not end-of-file }
  begin
    if (term = chr(9)) or (term = chr(13)) or (term = ' ') then
      begin
        pinname := word;                { save pin name }
        term := getword;                { read signal name }
        if (term = ',') or (term = chr(13)) or (term = chr(0)) then
          { output completed line of signal, socket, pin }
          writeln(parsefile,word,' ',socket,' ',pinname)
        else
          error := true         { signal name must end in comma or c/r }
      end
    else
      error := true             { pin didn't end in tab, space or c/r }
  end;
end;

begin (* main program *)
  linenum := 1;
  initfiles;
  term := chr(1);                       { assign non-zero value to term }
  error := FALSE;
  while term <> chr(0) do
  begin
    repeat
      term := getword;                  { get next word into word }
    until word[1] = '.';
    socket := word;                     { save IC socket name }
    ics := word;                        { also in another string }
    term := getword;                    { read pin name, probably }
    while (not error) and (term <> chr(0)) do
    begin
      if word[1] = '=' then
        ics := concat(ics,word)         { add IC type to socket string }
      else if word[1] = '.' then        { new socket name }
        begin
          socket := word;               { save new socket name }
          writeln(icfile,ics);
          ics := word;                  { save it here too }
        end
      else
        process_pin;
      if term <> chr(0) then term := getword;
    end;
    if error then begin
      writeln('Error on line ', linenum);
      writeln(errfile, 'Error on line ',linenum);
      error := false;           { set back to normal for next try }
    end;
  end;
```

Listing 13 continued on page 316

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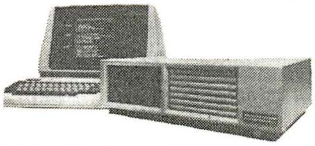


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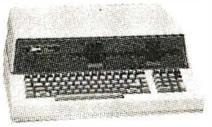
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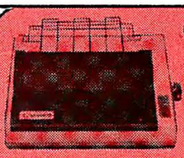
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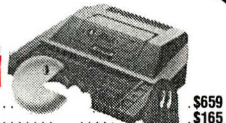
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Listing 13 continued:

```
  writeln(icfile,ics);          { write last of parts list }
  close(infile,result);
  close(errfile,result);
  close(icfile,result);
  close(parsefile,result);
  writeln('Finished');
end.
```

Listing 14: *The wire-list program in C.*

```
/* Program to process a CP/M file in the form:
        .SOCKET =ICTYPE
                PIN-NO SIGNAL, PIN-NO SIGNAL,
                PIN-NO SIGNAL, etc

If not supplied on the command line, the program asks for the
input file name.  It then asks for an output base file name, and
produces 3 output files, named BASE.ERR, BASE.IC, and BASE.PAR,
containing error messages, parts list, and parsed signal-pin list,
respectively.  The .PAR file, when sorted into alphabetical order,
becomes a network list which is useful for wire-wrap, PC layout,
error checking, and documentation.
*/

#define YES 1
#define NO 0
#define NULL 0

char error;
char    inname[20],      /* name of input file */
        outname[20];     /* base name of output files */
FILE    *infile,          /* channel number of input file */
        *errfile,         /* channel number of error file */
        *icfile,          /* channel number of ic file */
        *parsefile;       /* channel number of parse file */
int     linenum;         /* keeps track of line numbers on input file */
char    term;            /* what terminated each word */
char    word[40],        /* where getword puts the word it got */
        socket[40],      /* where socket name goes */
        ics[40],         /* string to save socket and ic type */
        pinname[40];     /* so it is */

main()
{
        error = NO;
        linenum = 1;
        InitFiles();                    /* open output files */
        while (1) {
                do
                        term = GetWord(); /* get next word into word */
                while (*word != '.');           /* find first period */
                strcpy(socket, word);           /* save ic socket name */
                strcpy(ics, word);              /* also in ic string */
                do {
                        term = GetWord();       /* read pin name */
                        if (*word == '=')       /* add ic type to */
                                strcat(ics,word);       /* socket string */
                        else if (*word == '.') {        /* new socket */
                                strcpy(socket, word);   /* save socket */
                                fprintf(icfile,"%s\n", ics);
                                strcpy(ics, word);
                        }
                        else
                                ProcessPin();   /* process pin/signal pr */
                } while (!error);

                printf("Error on line %d\n", linenum);
                fprintf(errfile, "Error on line %d\n", linenum);
                error = NO;             /* reset for next try */
        }
}

/* ProcessPin - process next pin/signal pair */
ProcessPin()
{
```

Listing 14 continued on page 318

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Listing 14 continued:

```
        if (*word == '$')       /* ignore any word */
                term = GetWord(); /* starting with $ */
        switch (term) {
        case ' ':
        case '\t':
        case '\n':
                strcpy(pinname, word);  /* save pin name */
                term = GetWord();       /* read signal name */
                switch (term) {
                case ',':
                case '\n':
                        fprintf(parsefile,"%s %s %s\n",word,socket,pinname);
                        break;
                default:
                        error = YES;
                        break;
                }
                break;
        default:
                error = YES;
                break;
        }
}

/* InitFiles - open all the output files */
InitFiles()
{
        char filename[20];

        printf("Name of input file -->");
        gets(inname);
        if ((infile = fopen(inname, "r")) == NULL) {
                printf("Can't open %s\n", inname);
                exit();
        }
        printf("Base name of output files -->");
        gets(outname);
        strcpy(filename, outname);
        strcat(filename,".IC");         /* make .IC file */
        if ((icfile = fopen(filename, "w")) == NULL) {
                printf("Couldn't open %s\n", filename);
                exit();
        }
        strcpy(filename, outname);
        strcat(filename,".ERR");        /* make .ERR file */
        if ((errfile = fopen(filename, "w")) == NULL) {
                printf("Couldn't open %s\n", filename);
                exit();
        }
        strcpy(filename, outname);
        strcat(filename,".PAR");        /* make .PAR file */
        if ((parsefile = fopen(filename, "w")) == NULL) {
                printf("Couldn't open %s\n", filename);
                exit();
        }
}

/* GetWord - gets next word into global string word */
GetWord()
{
        int i;
        int c;

        c = getc(infile);       /* get character from input file */
        while (!StartOfWord(c) && c != EOF) {   /* pass by white space */
                ChkForNewLine(c);
                c = getc(infile);
        }
        if (c == EOF)
                HandleEOF();

        i = 0;          /* assemble the word now */
        do {
                word[i++] = c;          /* build string */
                c = getc(infile);
                ChkForNewLine(c);
        } while (!EndOfWord(c));
        word[i] = '\0';                 /* tack on end of string char */
```

Listing 14 continued on page 320



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Listing 14 continued:

```
        return (c);                     /* return termination character */
}

/* ChkForNewLine - see if character is a newline. bump line counter */
ChkForNewLine(c)
char c;
{
        if (c == '\n')          /* if new line character */
                linenum++;      /* bump line counter */
}
/* HandleEOF - take care of end of file condition */
HandleEOF()
{
        fprintf(icfile,"%s\n",ics);     /* write out last of parts list */
        fclose(infile);         /* close input file */
        fclose(icfile);         /* close .IC file */
        fclose(errfile);        /* close .ERR file */
        fclose(parsefile);      /* close .PAR file */
        printf("\nFinished\n");
        exit();                 /* go back to operating system */
}

/* StartOfWord - see if c is a start of word character */
StartOfWord(c)
char c;
{
        switch (c) {
        case '\n':
        case '\t':
        case ' ':
                return (NO);    /* not start of word char */
                break;
        default:
                return (YES);   /* it IS a start of word char */
                break;
        }
}

/* EndOfWord - see if c is an end of word character */
EndOfWord(c)
char c;
{
        switch (c) {
        case '\n':
        case '\t':
        case ' ':
        case ',':
                return (YES);   /* it IS an end of word char */
                break;
        default:
                return (NO);    /* not an end of word char */
                break;
        }
}

gets(s)
char s[];
{
        int c;

        while ((c = getchar()) != EOF && c != '\n')
                *s++ = c;
        *s = '\0';
}
```

review of these languages and compilers. However, in the course of the many long hours of fussing with these products trying to get them all to run the programs, we developed some likes and dislikes, which you may be interested in knowing. They should be regarded merely as opinions.

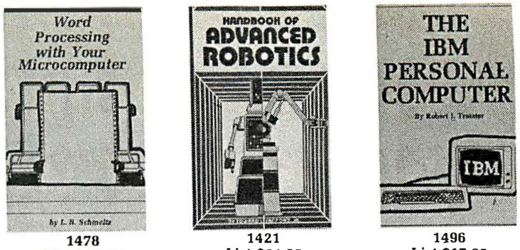
First, some observations about the Pascal compilers. During the process of getting these two programs (especially the wire-list program) to run on the Pascal compilers, our previous enthusiasm for Pascal has diminished a bit. It is *not* as portable as we expected. The language itself is basically standard, but of the four types of Pascal compilers tested, no two of them handled file I/O in the same manner. Pascal file I/O is clumsy at

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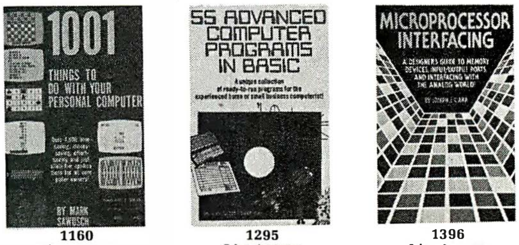
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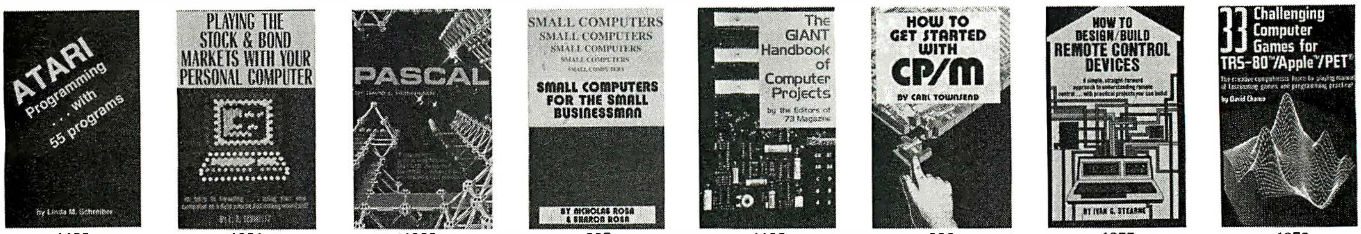
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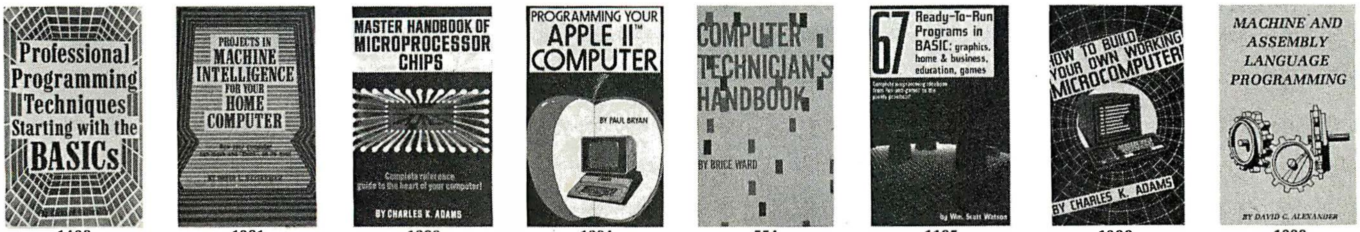
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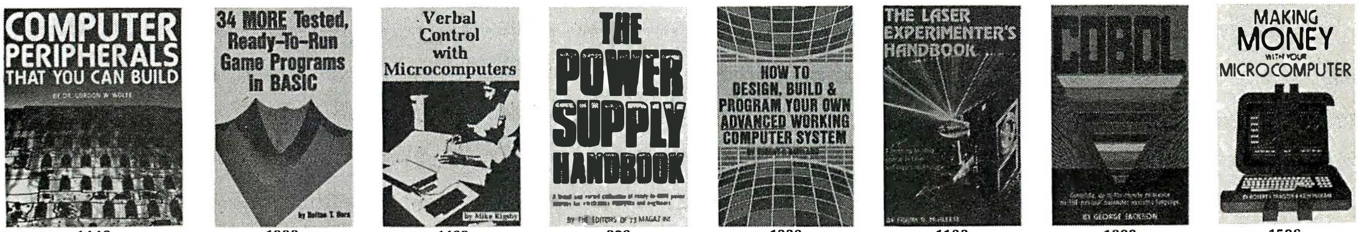
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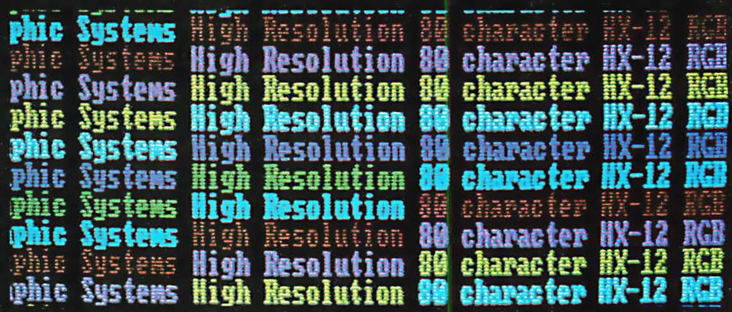


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Pascal Compilers				
Pascal/Z, Ithaca Intersystems, V4.0	2276	8052	141	34.0
Pascal/MT +, Digital Research, V5.5	1637	11,511	86	52.0
JRT Pascal, JRT Systems, V2.0	1410	24,194	70	171
UCSD Pascal, Softech, IV.03	2373	20,805	67	288
UCSD Pascal, Softech, IV.1 with Z80 Native-Code Generator	3398	21,830	185	287
Pascal/MT + 86, 8-MHz 8086, Digital Research (floppy disk)	2491	14,192	58.5	51.9
(hard disk)	2491	14,192	50.2	15.1
C Compilers				
C, Telecon Systems	1392	6948	169	22.8
C/80, The Software Toolworks, V2.0	1127	4434	67	24.2
CW/C, The Code Works, V1.0	1439	5393	125	24.2
BDS C, BD Software, V1.46	1640	7132	37	26.5
C, Supersoft, V1.1.0	1115	21,338	124	28.0
Q/C, Quality Computer Systems, V2.0b	1068	8731	89	30.5
Aztec C, Manx Software, V1.04	1279	4604	122	30.1
C, Whitesmiths Ltd., V2.1	1366	21,813	296	40.1*
C, Infosoft Systems, V2.03	1518	10,918	176	54.0
C86, Computer Innovations, V1.29B (8-MHz 8086)	1271	14,464	79	21.8

*Failed to close output file. Estimated time.

Table 5: *Performance of the Pascal and C compilers running a wire-list program that required file reading and writing and simple string processing. Memory used includes necessary library routines and p-code interpreters.*

best, and that's one reason why the Modula-2 language may catch on.

The Pascal documentation we received was generally complete but overwhelmingly voluminous and, in some cases, difficult to read with 100-plus loose-leaf pages. But then Pascal *is* a big language. Softech's four manuals were typeset and nicely bound. The Pascal/MT+ and Pascal/Z manuals had invaluable indexes, which we used a lot.

We had few problems in getting the wire-list program to run with either Pascal/MT+ or Pascal/Z. On the other hand, we had a great deal of trouble with both JRT Pascal and UCSD Pascal. We could not get the text files in JRT Pascal to work and finally had to resort to Binary files and checking for end of file (EOF) and end of line (EOLN) directly. Both Pascal/MT+ and Pascal/Z provided a convenient means to set the length of a string arbitrarily whereas neither of the other two did (it cannot be done in JRT Pascal, and in order to do it in UCSD Pascal, you must turn range checking off first). Though arbitrarily setting the length of a string is not something you need to do a lot, it was absolutely necessary in order for this program to work.

We liked the C compilers much better. The file I/O was handled pretty much the same with all compilers. The only differences were in the "getc" and "putc" functions. CP/M unfortunately uses a two-character sequence (CR-LF) to indicate end of line, and Unix uses the single character newline (LF). Because you might occasionally need to fiddle with a binary file, having "getc" and "putc" ignore all CR bytes (hex 0D) is intolerable. To get around this, you can do one of three things: (1) provide two separate "getc" and "putc" routines, (2) open the file in optional Binary or Text mode and have the routines remember which mode they were in; or (3) consider all files to be in the Binary mode.

The degree of compatibility among the C compilers is remarkable in that no C standard exists.

None of the compilers support the entire Unix Version 7 C language, but that would be expecting a lot. The degree of compatibility that does exist is remarkable since there is no C standard. All the compilers support "argc" and "argv" and file redirection in some way. The Aztec C compiler supports "long," "float," and "double" types very nicely. Only Whitesmiths supports bit fields.

The libraries included with the Supersoft, BD Systems, and Aztec compilers were the most complete (Supersoft had just about all the functions one could want, including all the various "printf" and "scanf" variations). Infosoft and BD Systems provided "long" and "float" operations but only as function calls (no expressions or data types). The Q/C compiler was the only one *not* to support structures (a collection of variables grouped together under one name).

The fastest compiler was the BD Systems C compiler. (Most other compilers were still chugging away when this one had already gone through two compile passes and a link and was beginning execution.)

Turnaround Time

The complete production cycle (compile, test, edit, and compile again) is an important consideration for programming productivity, and we think the compile-plus-load times are significant, especially in a profit-oriented environment. Hardware improvements such as hard disks and disk-simulating memory can influence this profoundly. But so can

the software environment. Softech's UCSD Pascal system and Digital Research's Speed Programming Package for Pascal/MT+ both offer a well-integrated environment for program editing, which is tied closely with the compiler and/or fast syntax checker.

Compiler Output

Most of the C compilers produce assembly language, which means another step is required to produce machine language. Usually, this extra step is a nuisance, but it is an advantage for incorporating machine-level code. This is probably the reason why C is experiencing such a growth in popularity and portability because it is relatively easy to change code-generation tables for another type of assembly language. Most of the C compilers can produce assembly language acceptable to the Microsoft M80 assembler, which means there is compatibility at the de facto industry-standard .REL level (.REL is the CP/M file extension for relocatable code files). The BDS compiler is fast and generates relocatable code directly, thus avoiding the assembly-language level entirely. But its output is not .REL-compatible. 'Tis a pity!

JRT Pascal has a remarkably low price at $29.95. Whether or not that is a bargain depends on the application.

Programming in C is fun, like driving a small car: it feels zippy, but beware of taking corners on two wheels!

Because it is a p-code interpreter, it is slow, but that may not matter for many applications. For those who want to learn Pascal with a minimum investment, it is an excellent value. If speed is important, we think you should look to a well-supported object-code compiler.

Frustrations and Kudos

We found Softech's UCSD P-system (p-code) difficult to bring up for the first time via a CP/M bootstrap. The delivery system is evidently not intended for the end user, but rather for original equipment manufacturers who will have a lot of customizing to do anyway. Support from Softech's staff was truly outstanding, however.

We didn't find as much to complain about with the C compilers, except we couldn't get Whitesmiths' version 2.1 to close the wire-list files properly. In fact, the execution time for Whitesmiths C in table 5 had to be estimated. The Whitesmiths people were notified of the problem, but they declined to send us a revised version of their compiler for testing. The Whitesmiths compiler is very complete and provides a lot of flexibility at each step in the compilation and link process. But this process requires *five* separate programs to go from source code to executable code. Its robustness seems to make it very

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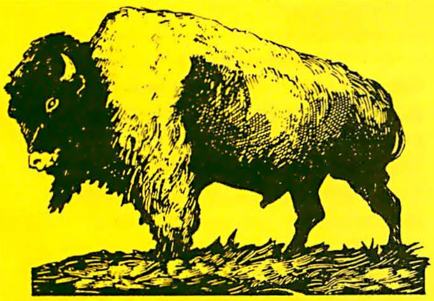
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large and slow (which may not be a problem with a hard-disk system). It's a professional's tool, like a Mack truck. It takes a long time to get it moving and to stop, but it can carry the freight. The language itself is essentially standard, but unfortunately the function names in the library are quite atypical. For example, the command "printf" is missing, though "putfmt" is similar but with different conversion specs, as in the following:

```
putfmt ("%i %p", x, str)
```

instead of

```
printf ("%d %s", x, str)
```

This kind of thing makes portability to and from other C systems more difficult, especially to Unix-like systems. Code generation, however, looked good.

The Aztec C compiler has virtually everything except bit fields and includes all the extended data types such as unsigned, long, float, and double, which are missing from most of the others. It also has full macro substitution in the preprocessor, and we found it to have good source compatibility with other C systems except for the "getc/putc" problem with CP/M mentioned before (use "agetc" instead).

C/80 has unsigned numbers, type casts, good debugging aids, and good portability of source code to other systems and is an all-around solid product and good deal at $49. We especially appreciated the trace and execution-time-profiling utilities that came with C/80. With utility program CPROF you can see just how your execution time is distributed and where the greatest potential is for improvement.

Q/C has the advantage of coming with the source code for the compiler (written in C of course), so you can see what makes it tick and, in the process, *really* learn C.

We had available for test only two 16-bit compilers (both for the 8086): Pascal/MT+86 from Digital Research and C86 from Computer Innovations. Both ran the programs without any changes on the first attempt. C86 seems to have all of the features of Aztec C and is claimed to be entirely source-level compatible. If so, C86 and Aztec C form a nice software bridge between the 8080 world and the 8086 world. This is also true for Pascal/MT+, by the way.

Computer Innovations has a code optimizer in the works, and Digital Research has a C compiler cooking. By the time you read this, several more exciting products will surely be available, especially for the C language, since this field is bursting with the labors of love of some very talented people who work with C all day, then go home at night and work with it for fun.

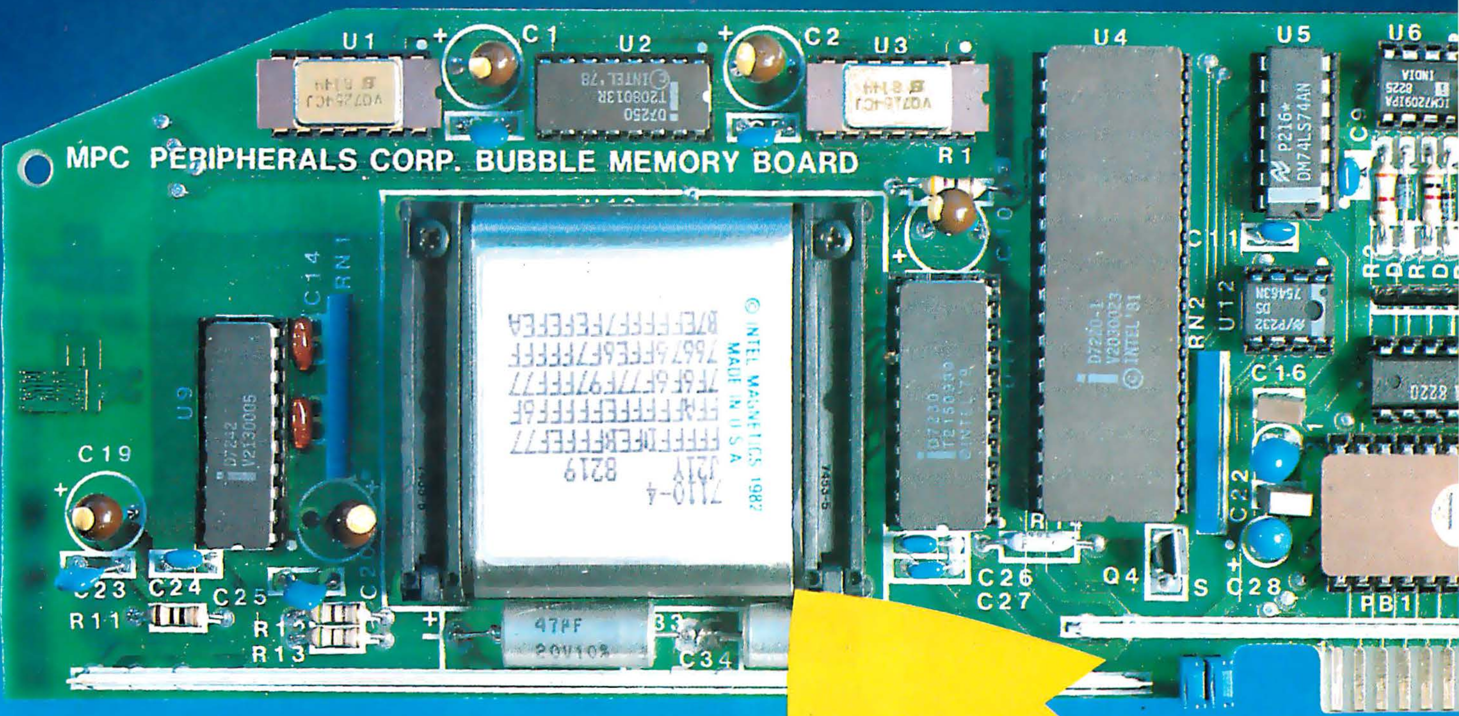
The Joy of C

We're not knocking Pascal; its place in the world as a versatile and safe language is quite secure. But C was more fun to work with. Programming in C is a bit like driving a small car: it gets the job done quickly, briefly, and with a minimum of restrictions. It feels zippy and maneuverable. But you can get into a jam if you take too many corners on two wheels! When it won't run right it can be puzzling until you see your blunder, a blunder that Pascal might have warned you about. It is quite possible to write clever, innovative code that you may not understand six months later. It is equally possible, however, to write clear, structured, well-documented code that is a delight to produce and read. Please do so, by all means. ■

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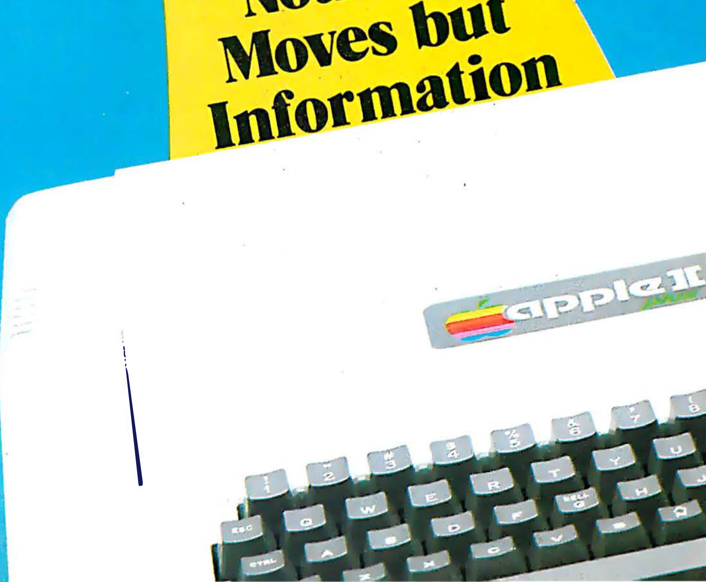
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Whitesmiths C Compiler

Larry Reid and Andrew P. McKinlay
Datatec Computer Systems Ltd.
344 Second Ave. S
Saskatoon, Saskatchewan
S7K 1L1, Canada

C is a high-level structured language that offers a concise and regular syntax, along with great flexibility. A general-purpose language, C's consistency makes it easy to use and remember. Its flexibility allows programmers to get very close to machine level when necessary, yet it still retains the features of a high-level language. It encourages programmers to write modular programs, not by restricting them to certain language features but rather by making modular programs a natural result of thinking in C. Its modularity helps programmers when writing large applications programs, while its ability to get close to the machine level also makes it an excellent systems-programming language. Listing 1 gives an example of a program written in Whitesmiths' flavor of C.

The definitive description of C is *The C Programming Language* by Brian Kernighan and Dennis Ritchie (see reference 2). This book contains a tutorial on C, the C reference manual, and many examples that demonstrate both the C language and a good programming style. The reference manual is the definition of the C language. You should have some knowledge of programming before you read this book. A good review of the C language appeared in *Electronics* magazine (see reference 3).

We have evaluated the Whitesmiths C compiler package using the following criteria: amount of language supported, portability of the compiler and compiled programs, ease of use of the compiler and compiled programs, efficiency of the compiler and compiled programs, the support offered by Whitesmiths, and the cost of the package. (To prevent you from getting lost in the maze of jargon, we have included a glossary of compiler terms—see the text box on page 334.)

At a Glance

Name
Whitesmiths C compiler

Type
Compiler for the C programming language

Manufacturer
Whitesmiths Ltd.
Building B
Parkway Towers
485 U. S. Route 1 S
Iselin, NJ 08830
(201) 750-9000

Price
$700, plus $50 media charge

Format
RK05 hard-disk packs, 9-track tape, RX01 8-inch floppy-disks, and CP/M single-density single-sided 8-inch floppy disks

Computer
Versions of the compiler are available for the following operating systems and processors: CP/M and derivatives (for Intel's 8080 and 8085, Zilog's Z80), Unix, Idris, RSX-11, RT11, RSTS, IAS (LSI-11, PDP-11), VMS (VAX-11), and Versados (Motorola 68000). The CP/M version requires at least 60K bytes of memory.

Documentation
Two manuals

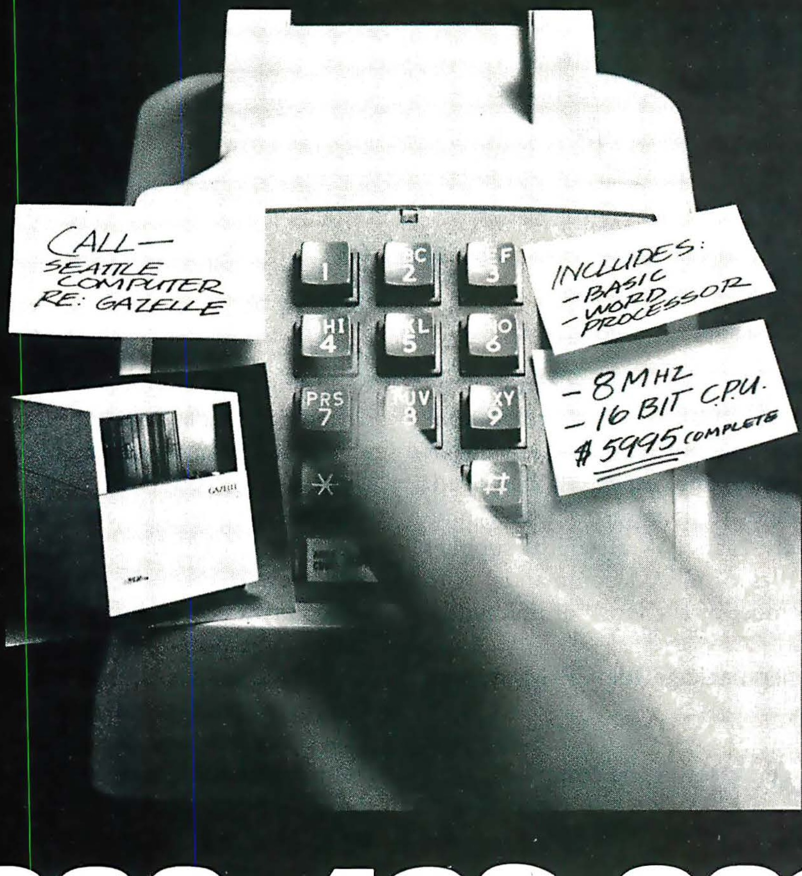
Audience
Serious programmers

Contents of the Package

Whitesmiths' products are available on RK05 hard-disk packs, 9-track tape, RX01 8-inch floppy disks, and CP/M single-density single-sided 8-inch floppy disks. (We reviewed the CP/M-disk version.) The documentation consists of two printed manuals, bound with plastic rings inside a plastic cover.

The software itself comes in relocatable form, with an

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Listing 1: *A sample C program that totals the number of lines, words, and characters that are input.*

```
/* count lines, words, and chars. in input */

#include <std.h>

#define NEWLINE '\n'
#define BLANK   ' '
#define TAB     '\t'

main()
        {
        TEXT c;
        COUNT nl, nw, nc;
        BOOL inword = NO;

        nl = nw = nc = 0;
        while(EOF != (c = getch())){
                ++nc;
                if(c == NEWLINE)
                        ++nl;
                if(c == BLANK || c == NEWLINE || c == TAB)
                        inword = NO;
                else if(inword == NO){
                        inword = YES;
                        ++nw;
                        }
                }
        putfmt("%i lines, %i words, %i chars.\n", nl, nw, nc);
        }
```

executable version of the linker. Before you can use any part of the package, you must link the relocatable modules with routines from the various libraries. This is a nuisance, but only a minor one, especially because it allows you to make changes to some aspects of Whitesmiths' programs relatively easily. Whitesmiths supplies some submit files (i.e., files of CP/M commands) with the CP/M version to do most of the work of linking the programs.

Whitesmiths' C compiler package for CP/M systems contains:

- pp, p1, and p2: the three passes of the compiler
- an: a-natural assembler
- anat: a-natural translator
- ld80: CP/M link editor
- lib: a librarian program
- rel: a program for inspecting relocatable files
- clib: a portable subroutine library
- mlib: a machine-dependent subroutine library
- documentation

The Preprocessor pp

The first pass of the compiler is a macro processor (known as the preprocessor), called pp. It interprets certain lines in a file as commands. These commands permit definitions of symbols as other symbols (constants), definitions of parametized macroinstructions, conditional acceptance or rejection of lines in the input file, and inclusion of other files in a file.

From the C programmer's standpoint, these facilities are most useful. The definition of symbolic constants makes programs more readable and more easily modifiable. For example, suppose the value −1 means end-of-file in some program. If you have to change the end-of-file value, you must recode each −1 individually to ensure that you convert only −1s that mean end-of-file. This process is tedious and error prone. If, however, you could define the symbol EOF to mean −1, then to change the end-of-file value you need only rewrite the line defining EOF as −1.

Macroinstructions can be used to implement subroutines that do not have to worry about the type (i.e., integer, long integer, floating point) of their arguments. It is often convenient to put commonly used symbol and macro definitions in one file and to use the preprocessor to include them with each C source file. For this purpose, Whitesmiths supplies a standard *header file*, called std.h. (See listing 1 for examples using some of the preprocessor features.)

Because the preprocessor can evaluate simple conditions, lines may or may not be compiled, based on condi-

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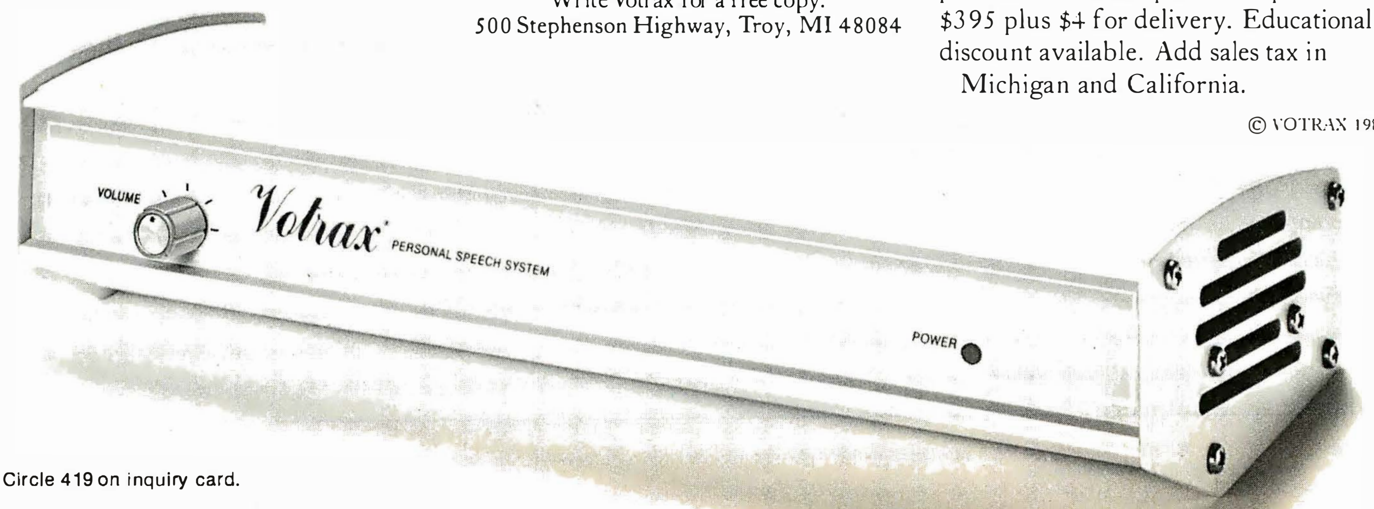
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tions existing at compile time. This is a convenient way of turning on (or off) debugging output or of compiling several slightly different versions of the same program. pp is also useful by itself as a general macro processor for an assembler because none of its operations are inherently dependent on C. It could be used, for example, as a macro processor for an assembler.

The Parser p1

The C parser, p1, analyzes a program syntactically, reports any errors, and passes flow graphs and parse trees to the code generator. Whitesmiths' parser accepts the full set of C commands; including long integers (usually 4 bytes), floating-point numbers, and structures.

The Code Generator p2

An assembly-code generator that creates an assembly-language program for the target machine, p2 is the only target-machine-dependent program in the compiler itself. The CP/M version produces a-natural assembly code; a-natural is an assembly language for 8080-type processors.

Using assembly language as an intermediate form has several advantages. The compiler-writer has a simpler interface to many operating systems, because most systems have an assembler. You can inspect, or even modify, the assembly-language program. This optimization of code after compilation is a good way of obtaining programs that are both fast and small. You let the compiler do most of the work, and you can then do what optimization is necessary.

The a-Natural Assembler an

The a-natural assembler for the 8080, an, was developed by Whitesmiths. For an assembly language, a-natural has a rather unique syntax. This syntax is supposed to make a-natural easier to read and write than ordinary assembly language. (One of the authors, who has no experience with 8080 assembly languages, finds a-natural easy to read, although we both fear that no assembly-language experience can make writing 8080 code less than frustrating. See listing 2 for a comparison of a-natural and standard assembly language.) The output of an is a relocatable object file, so an can be used as an assembler by itself.

The a-Natural Translator anat

anat translates a-natural assembly language to standard assembly language that is accepted by either the ISIS-II asm80 or the Microsoft Macro-80 assembler. It is useful for interfacing C or a-natural programs to existing 8080 code.

The 8080 Link Editor ld80

Relocatable object modules produced by an are linked by ld80. It also produces an executable machine-language program. The input routines may be from several files. C supports (or rather, does not prevent) separate compilation of routines in one program. The linker loads modules from any library, if they are needed. By default, the CP/M version loads programs starting at location hexadecimal 100 in memory. The user can specify a different starting address and separate loading addresses for

A Glossary of Compiler Terms

Compiler writing has become a science. In developing this science, compiler authors have coined many terms or have given old terms new meaning. Here is a glossary of some common compiler terms. Nonitalicized words are cross-referenced to other entries in this glossary.

Code generator: *The last pass of the* compiler. *It produces either an assembly-language or relocatable machine-code version of the high-level program.*

Compiler: *A program or series of programs that takes a program written in a high-level language (e.g., C, PL/I, ALGOL) and translates it into a low-level language. This low-level language is usually, but not always, the assembly or machine language of the host computer.*

Compiler-compiler: *A program to help write* compilers. *It takes a* grammar *for a language and generates a* parser *for a* compiler.

Cross-compiler: *A* compiler *that generates machine- or assembly-language programs for a computer other than the host computer (e.g., a compiler running on a PDP-11 that produces machine code for an 8080).*

Data Type: *The logical class of a data item (variable). Some data types are string, integer, and floating point.*

Executable: *An executable program is a program completely ready to run on a computer.*

Flow Graph: *A description of some properties of a program.*

Grammar: *A high-level description of the* syntax, *or construction rules, of a language.*

Library: *A special file that contains many useful, and usually related,* modules *or subfiles. The built-in subroutines of a language are commonly stored in a library.*

Link Editor: *See* linker.

Glossary continued on page 338

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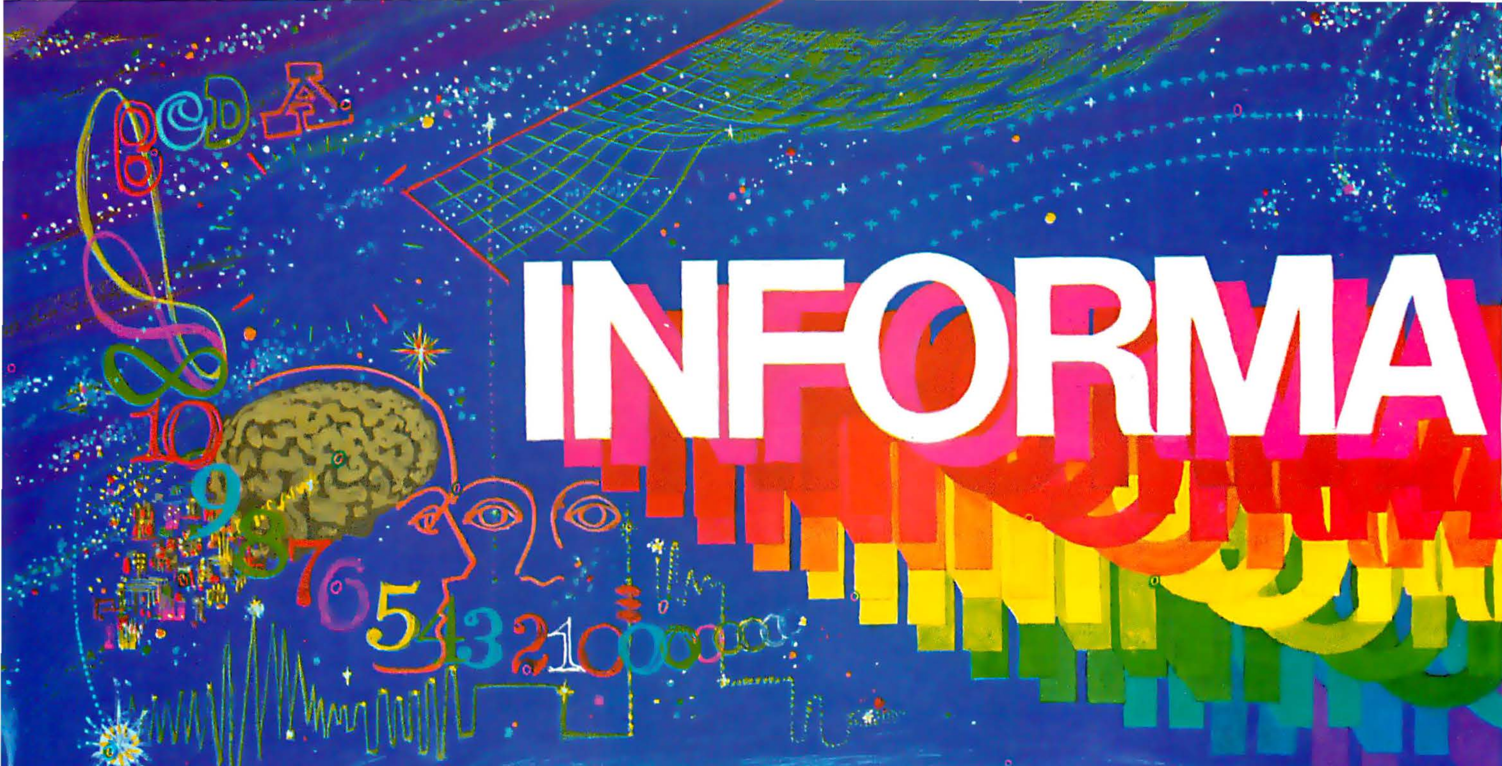
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No "Cryptic Commands"
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Linker: *Also known as* loader *or* link-editor. *A program that takes* relocatable modules, *combines them with any needed routines from available* libraries, *and produces an* executable *program.*

Loader: *See* linker.

Macroinstruction: *A macroinstruction (or simply a macro) is a predefined piece of text that may be inserted as a block into some other text. Frequently used pieces of code are often made into macros; instead of writing out the code each time, the programmer only has to name the macro. Macros may have arguments much like subroutines; however, a macro is not the same as a subroutine. Many general assembly-language books discuss macros.*

Module: *A piece of code. Usually refers to a block of machine code.*

Object Module: *A module of machine code. The code is usually in* relocatable *form.*

Parser: *The first or second pass, or program (see* preprocessor*), of a compiler. It produces* flow graphs *and* parse trees*: to be passed on to the code generator.*

Parse Trees: *A description of some properties of a program.*

Preprocessor: *If present, it is the first pass of the compiler. Typical duties of the preprocessor include macro expansion, textual substitution, and passing or not passing lines to the output depending on some conditions.*

Relocatable Module: *A relocatable module is an* object module *where one or more memory references have not been defined (e.g., the destination of a jump or the address of a variable hasn't been defined). Using a* linker, *a relocatable module can be made into an executable module that can run anywhere in free memory.*

Semantics: *The meaning of a program.*

Syntax: *The structure of a language.*

instructions and data (useful for programs that will be put into read-only memory).

The Librarian lib

The lib program maintains files, known as libraries, that contain many other files. The user can create, add to, and delete from libraries and can extract names and copies of modules in the library. Its primary use is in maintaining libraries of compiled subroutines that may be connected by the linker.

The Portable Library clib

Whitesmiths standard subroutine library, clib, contains subroutines callable from C and a-natural routines. In clib are various routines to do I/O (input/output), string handling, memory management, number-to-text and text-to-number conversions, and a convenient sorting routine. The CP/M-dependent clib has a routine to allow direct CP/M system calls from C programs. Table 1 lists some of the routines found in clib.

The Machine Library mlib

The machine-dependent mlib library of routines boosts the power of the 8080. Most of these routines do arithmetic on various types of numbers such as integer, long integer, and floating point.

Documentation

A set of manuals comes with the compiler. These manuals cover all the programs and routines in the package. They do not cover the C language itself in any detail. Kernighan and Ritchie's *The C Programming Language* is not included in the package but is available from Whitesmiths. You should also be able to find the book at your local computer shop or at a university bookstore.

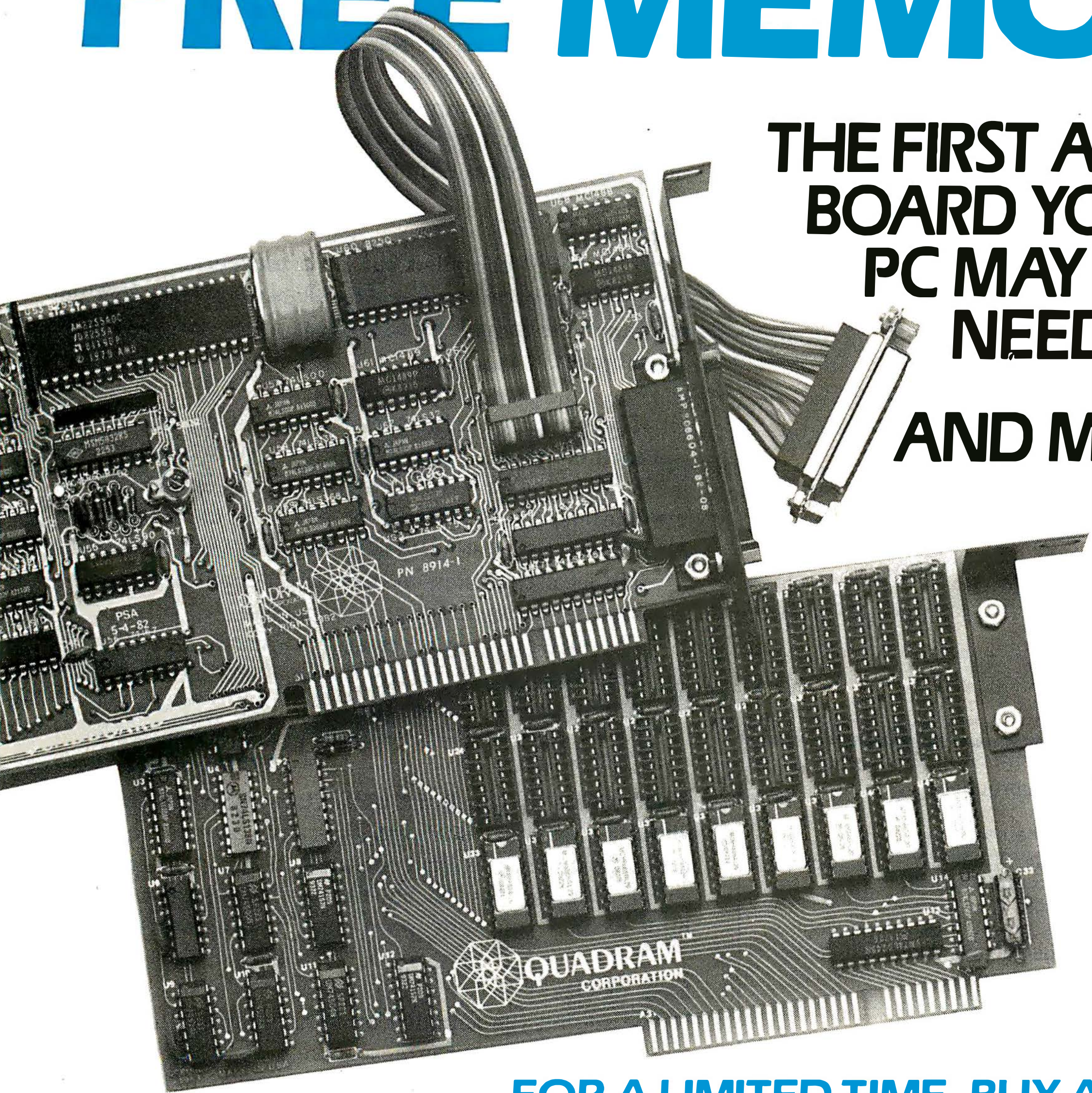
Use

Each program compiled with Whitesmiths C can be run under CP/M by simply typing its name. You may give additional strings on the command line to be passed to the program as arguments. The program may interpret these arguments as flags or file names. Flags specify optional actions or values for the program. For example, the flag most commonly used by CP/M users directs the nontext output of some of the programs to a file other than the default. In all cases, the program supplies a reasonable default value.

Most of Whitesmiths' programs, and all programs normally compiled under it, support the notion of command-line I/O redirection. This is an incredibly simple and *powerful* tool that allows most normal programs to read and write disk files, I/O devices, or the terminal in the same manner and without changing the program at all. (See the accompanying text box about I/O redirection on page 342.)

A CP/M submit file (command file) for operating the compiler is part of the package. This submit file runs each pass of the compiler and assembles and links a single C source file. C permits, and even encourages, separate compilation of each file that makes up a program; however, this submit file is inadequate. Also, each pass of the compiler can take some flag values from the command line to specify optional actions for that pass. The submit-file mechanism does not allow the user to conveniently set these flags. (We wrote a program to drive the various passes of the compiler, the assembler, the librarian, and the linker so that a one-line command can perform a large number of operations, with a clean, concise, and consistent syntax. This driver program makes using the compiler much easier.)

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(5) All receipts, coupons, and proof of purchase forms must be mailed together in order to qualify for a memory board. Must be postmarked no later than March 1, 1983, and received by Quadram by March 15, 1983. Void where prohibited or taxed.

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Listing 2: *A comparison of a-natural with assembly language. In this example, both programs are a code sequence for subtracting two 16-bit integers, one at location x, and the other at location 4 + de.*

a-natural

```
a = *(bc=&X) - *(hl=4+de) -> *bc =
*(bc+1) -^ *(hl+1) -> *bc
```

assembly language

```
LXI B,X      INX B
LDAX B       LDAX B
LXI H,4      INX H
DAD D        SBB M
SUB M        STAX B
STAX B
```

Library of Subroutines

alloc	allocate space on the heap
cmpstr	compare two strings for equality
cpm	do CP/M and CDOS system calls
cpystr	copy multiple strings
decode	convert arguments to text under format control
encode	convert text to arguments under format control
errfmt	format output to error file
exit	terminate program execution
fill	propagate fill character in buffer
free	free space on the heap
frelst	free a list of allocated cells
getfiles	collect files from command line
getflags	collect flags from command line
getfmt	format input from standard input
instr	find first occurrence in string of characters in set
isalpha	test for alphabetic character
isdigit	test for digit
islower	test for lowercase character
isupper	test for uppercase character
iswhite	test for whitespace character
lenstr	find length of string
lower	convert characters in buffer to lowercase
max	find maximum of two numbers
min	find minimum of two numbers
notstr	find first occurrence of character not in set
onexit	call function on program exit
prefix	test if one string is a prefix of the other
putfmt	format arguments to standard output
putstr	copy multiple strings to file
remove	remove a file
scnstr	scan string for character
sort	sort items in memory
squeeze	delete character from buffer and compress
tolower	convert character to lowercase if necessary
toupper	convert character to uppercase if necessary
uname	create a unique file name

Table 1: *Some of the routines supplied by Whitesmiths in the subroutine library clib.*

Language Completeness

Whitesmiths' compiler compiles the full standard C languages as defined in Kernighan and Ritchie's book. We found only a few very minor syntactic differences, and Whitesmiths' compiler recognizes a few extensions to the standard. Anyone who has used or is using Unix version 7 C will probably notice no difference at all.

Portability

Whitesmiths' compilers run on a number of operating systems and processors (see At a Glance text box). Within this family of compilers, a few possible portability problems remain:

1. The processor influences the size of an integer for each compiler. The 8080-family processors (i.e., the LSI-11, the PDP-11, and the MC68000) have 16-bit integers; the VAX machine has a 32-bit integer.
2. The host operating system influences the length of, and legal characters in, external identifiers (i.e., subroutine names and global variables).
3. The 8080 does not necessarily compare 16-bit quantities correctly. Therefore, the results of a comparison can differ between an 8080 and a PDP-11. (We have yet to encounter this problem in actual use.)

Of course, if you insist on writing programs that use absolute memory locations, operating system calls, or other machine-dependent features, expect portability to suffer. Whitesmiths' documentation has a section full of hints to help you write more portable programs.

Ease of Use

The submit file supplied by Whitesmiths to drive the compiler is adequate for most small programs, but it's inflexible and inadequate for larger programs. Were Whitesmiths' programs not so easy to use individually, it would have been very difficult to build the driver program mentioned earlier. (This is a good illustration of the idea of *software tools.* That is, the idea is to write programs so that they communicate with other programs in a standard way. For further information, see reference 1.)

Programs compiled by Whitesmiths' compiler are easy to use because the command-line arguments and I/O redirection facilities encourage the programmer to write programs with an intelligent interface to the user. The subroutine library contains some very useful routines that can make the programmer's task quite a bit easier, depending on the application. (See table 1.)

While explaining the ease of use of the C language itself is beyond the scope of this article, we will make the bold statement (without giving any support for our position) that C is the best general-purpose programming language. The portable library also contains many other useful routines. We make extensive use of it.

Efficiency

We'll discuss the classic definitions of efficiency: speed and object-code size. The compiler, assembler, and linker

I/O Redirection

To some degree or another, all C programs operate with certain I/O conventions. The primary notion is the concept of standard I/O locations. Most C programs write their output to "the standard output," which, by default, is the terminal. However, with a little bit of wizardry on the command line, this output can be sent to a disk file, device, or I/O port. Similarly, most C programs will read from "the standard input." This too is, by default, the terminal keyboard. Again, this can be redirected at run time, so that a program that normally reads from the terminal can also read from a disk file or device.

How to Redirect

The wizardry is the command-line notation. The > (greater-than symbol) means "send the output to whatever is named next on the command line." The < (less-than symbol) means "take input from whatever is named next on the command line." For example, pr, a program to print source listings, writes its output to the standard output. To send its output to a printer on a CP/M system:

```
pr file1.c file2.c >lst:
```

while to send it to a disk file:

```
pr file1.c file2.c >b:files.out
```

We liked this feature; it allows you to string several programs together to perform complex tasks. A more esoteric, but perhaps more powerful, use of this feature is the following case: suppose you have to do the same series of editor commands on several files. Simply create a file, let's call it script, *that contains the editor commands for each file. This is often easier to do than typing each command because most editors have a copy facility. When this is done, type:*

```
ed <script
```

and go get a cup of coffee. All the editing is done automatically for you.

There is also a standard place where error messages are written. It is always the terminal and is not redirectable. In this way, a program may write error messages even if the bulk of the output is being redirected.

Why Redirect?

Redirectable output is a very powerful tool. It means that the same program can write to a file, a device such as a printer, or to the terminal with no change to the program itself. It encourages programmers to write well-defined programs with clean interfaces. Simple programs with simple interfaces may be strung together by having one program write its output to a file, and then having another program use that file as input, and so on. Users of the Unix operating system can create pipelines *like this without intermediate holding files. You can save a lot of time and money by doing new things with old programs instead of writing new programs that work in only one specific case.*

The definitive work on the subject of software tools is the book Software Tools *by Kernighan and Plauger. (See reference 1.) They discuss the concept of stringing together programs in depth, and they present many programs that have proved themselves to be good building blocks.*

are quite large on the 8080—between 30K bytes and 50K bytes. A full 64K-byte CP/M system is almost a requirement to run the compiler. For CP/M users, you almost certainly need two 5¼-inch double-density drives or an 8-inch drive. The compiler itself runs relatively fast: a large C file (200 lines) can be compiled and assembled in a minute or two on a 4-MHz Z80A. The link times, however, are another story. Most C programs take 2 to 5 minutes to link; really large ones approach 10 minutes of link time. It's great for catching up on your reading, but, more often than not, it's annoying.

The compiled programs are fast. The figures in table 2 were given in *The C Letter* (see reference 5) for a bubble sort of a 256-integer descending-order vector, into ascending order on a Texas Instruments 3-MHz TMS-9900 processor. As table 2 illustrates, C's reputation for speed is not unsupported.

The object-code size of a normal C program under CP/M is relatively large. This is because so much (i.e., I/O redirection, argument passing, etc.) must be done in each program. There is no free lunch: if you want these facilities, the code for them has to be somewhere. All is not lost, however. If you do not want or need I/O redirection or command-line arguments, the processing can be bypassed relatively easily by using a method described in Whitesmiths' documentation. This may save you about 4K bytes of object code, depending on the library routines your program uses. For example, the following program is 6K bytes long:

```
main( )
  {
  }
```

This program is 2K bytes and does no argument handling or I/O redirection:

```
_main( )
  {
  }
```

A rewriting of the assembler output by an *experienced* assembler programmer can usually result in a 15-percent decrease in code size; a careful rearrangement and rewriting of the whole program from scratch by the same programmer *may* save another 15 percent. (Note this does

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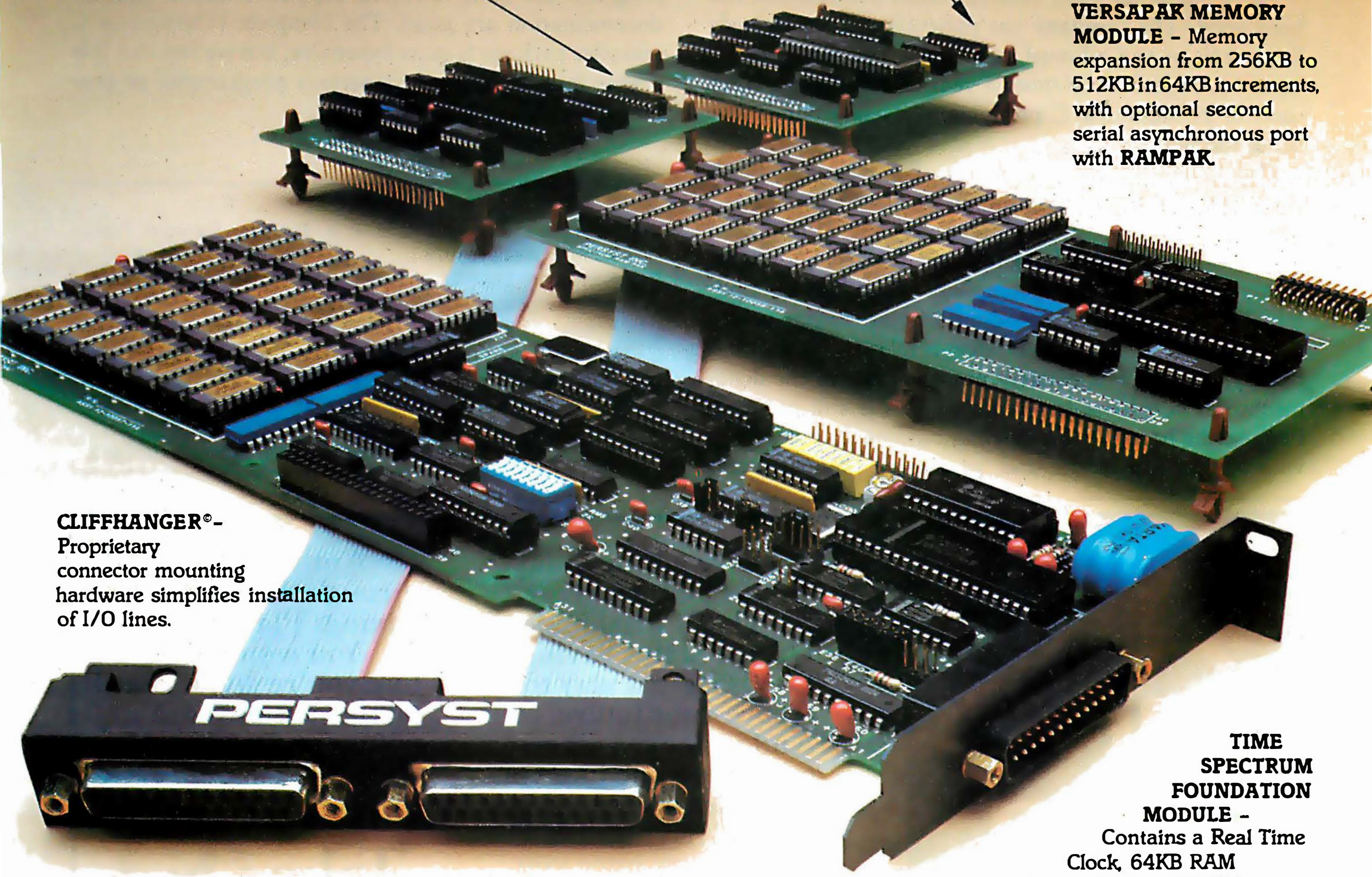
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Language	Time (Seconds)
Pascal P4	29
Pascal Birch-Hansen	29
BASIC Interpreter	240
BASIC Compiler	12
fig-FORTH	25
PL/I	3
Whitesmiths C	3
Whitesmiths C (using pointers)	2

Table 2: *The results of a bubble sort of a 256-integer descending-order vector into ascending order show the speed of Whitesmiths C.*

not imply that an assembler programmer will always win by 30 percent.) Compilers, unlike humans, do not get tired and do not usually make mistakes. With the cost of programmers going up and the cost of memory going down, the savings of writing in C can only increase.

Support

The support we have received from Whitesmiths has been good. The company has patiently and courteously listened to us and allowed us to speak our piece. *The C Letter*, produced three times a year, is a good forum for users of Whitesmiths C products. A users group is also being formed.

The documentation is excellent. The manuals offer a clear and concise description of their subject matter. They're well organized, so it's relatively easy to find what you're looking for. We have found only a few bugs in the documentation. Our sole complaint about it is the binding. The two manuals are bound in plastic rings with a plastic cover. This type of binding is relatively cheap and clumsy, and we immediately put one copy of the documentation into loose-leaf binders. This is still not ideal because the holes for the original binding do not line up with a loose-leaf binder and, as a result, the pages tear and come loose. It is somewhat annoying that otherwise excellent documentation is packaged in a relatively unusable form, especially when so much impractical documentation is packaged very smartly.

Price

This compiler is expensive. The cost is currently about $700. Why pay so much? One must weigh the costs and benefits. The salaries of two people for one week *almost* make the difference between Whitesmiths C and another leading C compiler and more than cover the difference between Whitesmiths C and most Pascals. We feel we easily saved that one week's pay in the first month we had the compiler.

Conclusions

Whitesmiths' C compiler compiles the full standard C language and is highly portable, as are the programs written under it. It is easy to use and supports command-line I/O redirection. The linker is slow, but most compiled C programs are quite fast. The support available and the documentation are good. The complete Whitesmiths C compiler package is quite expensive, but we feel that it is a wise investment for any serious programmer or programming shop. ■

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Structured Systems Group of Oakland, California, has developed a database/report writer program called Analyst and a general-purpose sort/merge utility called Qsort. Although the two programs are marketed separately, they are designed to be used together to provide a full database management system (DBMS).

A few words on the system: a DBMS is a program that accepts data in a format that you define, processes it as you request, and then outputs the data in the report format of your choice. Reports may take such forms as tables, checks, receipts, invoices, and appointment lists.

Structured Systems Group states that Analyst is designed to "keep customer and employee records, sales statistics, inventory lists, stock portfolios, schedules, name and address lists, student grades, class enrollment records, book and record collections, plus many more." For many limited tasks of this kind, Analyst alone would be adequate. For most applications, however, you will need both Analyst and Qsort.

Documentation

Two users manuals accompany Analyst. The first, 66 pages long, offers a clear and detailed description of how to generate a program to record the activities of five salespeople. It includes computations of commissions, subtotals, and totals as well as the formulation and printing of a tabular report. Each required keyboard entry command is listed, along with the video-terminal display it produces. A second Analyst manual containing 149 pages presents information that supplements the first. Both manuals give detailed instructions for using the CP/M operating system commands that are required to support Analyst.

Structured Systems' outstanding documentation makes learning to use the program relatively easy. Even the complex section on report generation is intelligible. (Incidentally, of the six DBMS programs I have reviewed in recent months, only this documentation is relatively free of typographical errors.)

To turn to Qsort for a moment, most of the instructions for its use appear in the larger Analyst manual, but a separate 22-page manual offers additional details about using Qsort to sort files that were not produced by Analyst.

Unfortunately, the three manuals lack indexes, which would facilitate finding and reviewing descriptions of any program function covered in more than one manual. (Unless otherwise noted, "Analyst" or "DBMS" will refer to the combination of Analyst and Qsort for the remainder of this review.)

Operation

Analyst is written in CBASIC, a compiler and interpreter from Digital Research. The CBASIC compiler converts a programmer's high-level statements (source code) to nonexecutable intermediate code. When the program is run, the compiler translates the intermediate code into executable form. Because the Analyst package includes both the intermediate code for the program and the CBASIC interpreter, you don't need to purchase CBASIC or compile the program.

Analyst runs under CP/M version 1.4 or 2.xx and requires 48K bytes of RAM (random-access read/write memory) and at least one disk drive that can store 300K bytes. The parameter file can be modified so the program will run on microcomputers with less than 48K bytes of RAM, but a dealer should do this for you before you buy the package.

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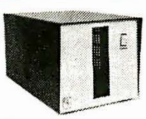
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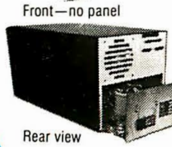
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Front—Tandon Panel



Front—no panel



Rear view

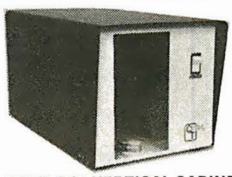
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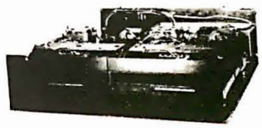
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At a Glance

Name
Analyst and Qsort

Type
Database management system (DBMS)

Manufacturer
Structured Systems Group Inc.
5204 Claremont Ave.
Oakland, CA 94618
(415) 547-1567

Price
Analyst: $250; Qsort: $100
Total: $350

Format
IBM soft-sector 8-inch single-density floppy disk; 5¼-inch Micropolis double-density, North Star DD, Zerox, Toshiba, Sharp, HP-125. Some other formats through dealers.

Software Required
CP/M operating system, version 1.4 or 2.xx. Analyst and Qsort are furnished in compiled intermediate code accompanied by a run-time interpreter.

Language
CBASIC

Computer System
Any microcomputer with at least 48K bytes of RAM and at least one 300K-byte disk drive. A 16-line by 64-column display; 24 lines by 80 columns improves operation. Printer required, preferably with 132-column print capability.

Documentation
Three manuals: one 149 pages, one 66 pages (Analyst); one 22 pages (Qsort)

Audience
Anyone who owns a microcomputer

essential. Because many program printouts require it, a 132-column printer is desirable.

At the start of Analyst, you designate the appropriate CBASIC run-time interpreter (for CP/M version 1.4 or 2.xx) and then specify either a 24-line by 80-column or 16-line by 64-column display. The program retains these selections, and you don't have to reenter them unless you make changes in your computer system. Next, the program asks for the date, and you have the option of entering it or hitting a carriage return to save time.

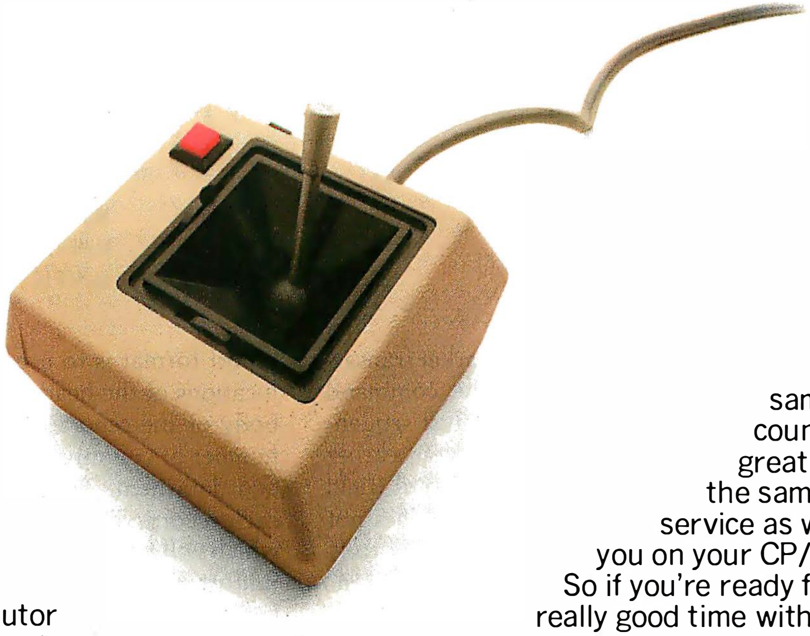
A Sample Application

I developed a stock-market record-keeping program as a learning exercise and so that I could demonstrate some of the program's functions. The program, called STOCK, computes stock rates of return and provides information the Internal Revenue Service requires for income-tax reporting. The stock-market file consists of five records, each including all the descriptive items (called fields) of information about one stock. Listing 1 shows the specification for the stock-market record file that I developed for STOCK. Analyst records can have up to 50 fields, but record length is limited to 255 characters (bytes). The total number of records possible is determined by the storage available on the system disks.

The first step in developing the stock-record program is defining the input data format. To do this, select the command DEFINE A DATA FILE from the menu. Analyst asks for the total number of fields in one record and then brings up each number field in sequence. Each number is accompanied by a program prompt asking the user to specify the length and data type of each field. Fields may be designated as numeric, integer, alphanumeric, or date. Alphanumeric fields can be up to 132 characters (numbers, letters, or spaces) in length. Numeric fields (decimal numbers) and integer fields (whole numbers) can be up to 14 characters (bytes) in length. Dates are stored as 6 characters.

To edit the file specification, you enter information sequentially in each field in the record and then go back to the beginning and display each field again to make any corrections. In other words, Analyst lacks a full-screen editing capability. After you complete the file specification, Analyst will print it, but you must have a 132- column printer. If you are using an 80-column printer, all characters in excess of 80 will overprint at the beginning of the line.

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Listing 1: *A completed file specification under the Analyst program. The uppermost section contains general features including file name, record descriptions (in this case, information about stocks), the number of data items (fields) in the record, and the total length of each record (all the fields together pertaining to one stock). The bottom section gives a number and name for each field, its position in the record (number of bytes into the record to where the field begins), its length, and its type.*

```
                              ANALYST FILE SPECIFICATION

FILE DEFINITION FILE NAME:    STOCK.FIL
DATA FILE NAME:               STOCK.DAT
DATA FILE DRIVE:              B
DATA FILE DESCRIPTION:        STOCK RECORDS
NUMBER OF ITEMS:                14
RECORD LENGTH                   94


                              RECORD SPECIFICATIONS

ITEM NO   ITEM NAME              ITEM POSITION  ITEM LENGTH   ITEM TYPE

    1     DATE PURCHASED               1            6         DATE
    2     COMPANY                      7            8         ALPHA
    3     NUMBER OF SHARES            15            6         INTEGER
    4     DIVIDEND                    21            6         NUMERIC  2 DIGITS TO RIGHT OF DECIMAL
    5     COST PER SHARE              27            6         NUMERIC  2 DIGITS TO RIGHT OF DECIMAL
    6     NET COST                    33            7         NUMERIC  2 DIGITS TO RIGHT OF DECIMAL
    7     COMMISSION                  40            6         NUMERIC  2 DIGITS TO RIGHT OF DECIMAL
    8     TOTAL COST                  46            7         NUMERIC  2 DIGITS TO RIGHT OF DECIMAL
    9     PER CENT RETURN             53            6         NUMERIC  2 DIGITS TO RIGHT OF DECIMAL
   10     DATE SOLD                   59            6         DATE
   11     GROSS SALE PRICE            65            7         NUMERIC  2 DIGITS TO RIGHT OF DECIMAL
   12     COMMISSION                  72            6         NUMERIC  2 DIGITS TO RIGHT OF DECIMAL
   13     NET SALE PRICE              78            7         NUMERIC  2 DIGITS TO RIGHT OF DECIMAL
   14     NET GAIN OR LOSS            85            7         NUMERIC  2 DIGITS TO RIGHT OF DECIMAL
```

Next, you enter the data for each stock-market transaction. To do so, select from the menu the command CREATE OR MODIFY A DATA FILE. Analyst sequentially brings up each data-field label as you earlier specified it. Then you type in the descriptive items (field data) for each stock purchase. Again, Analyst does not have full-screen editing capability, so you must return to the beginning of the record and display each field sequentially, making corrections as you go.

Analyst assigns a record number to each record as it is entered. When you are in the EXTRACT mode, you can retrieve and display records by specifying the number of the desired record. You can also sort the file using a key field of your choice and then retrieve a record by entering the value of the key field in the desired record. For example, I sorted the STOCK files in ascending alphabetical order on the COMPANY field. After selecting the EXTRACT mode from Analyst's menu, I entered EAL (Eastern Air Lines), and Analyst found and displayed all fields of the first record that had EAL in the COMPANY field. I could have continued and displayed the next record in the file by hitting the Return key.

Listing 2 is a sample report produced by Analyst from data in the STOCK data file. The best way to establish a report format is to use graph paper. You can specify the locations of the headings and the field data that go in the body of the report by entering the line number and the number of columns from the left margin for each heading and data item. There may be as many as five rows for each record. This allows you to generate mailing labels, which will be printed in a format that is one column wide (unfortunately, this is not as fast or inexpensive as printing multiple-column labels).

As many as five fields of one record may be designated "accumulators." You can use two other fields to perform mathematical operations (+, −, /, *), and the result will be deposited in the accumulator. In the STOCK example, field 9 (% RETURN) and field 14 (NET GAIN OR LOSS) are designated accumulators. Whenever the STOCK report is requested, the amount in the DIVIDEND field is divided by the amount in COST/SHARE and the quotient is printed in the % RETURN location. The TOTAL COST is subtracted from the NET SALE PRICE, and the difference is printed in the GAIN OR LOSS position.

You can designate additional accumulators to add data for subtotals or totals desired. For example, the field data in the two IBM stock records NET G OR LS could have

Text continued on page 358

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Listing 2: *A report generated by Analyst. Following instructions from the user, Analyst extracted this data from records of stock transactions. See listing 1 for specifications of the stock records.*

```
                        COMMON STOCK BALANCE SHEET

DATE PUR-COMPANY---# SHARES--DIVIDEND--COST/SHARE--NET COST--COMMIS--------
TOTAL COST--% RET---DATE SLD- GROSS SP----COMMIS-----NET SP-----NET G OR LS


12/17/80 EAL         #    100.  $  1.00    $ 12.00    $1,200.00    $ 50.00
$1,250.00   8.33 %  08/04/81  $1,092.00    $ 50.00      $1,042.00  $   -208.00


03/05/79 EXON        #    100.  $  3.30    $ 27.50    $2,750.00    $ 76.00
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Listing 3: *Completed file specification for the CBASE file used to time the performance of Analyst. The file specification follows the same general rules explained in the caption for listing 1. The data in the file, consisting of 2000 records, was generated by a CBASIC program. The STOCK NUMBER field contains random integers in the range 10,001 to 99,999. TYPE contains integers in the range 4000 to 8000, stepped by 2. QUANTITY also has random integers, this time ranging from 20,000 to 30,000. BASE METAL holds mixed alphanumeric data. The file exceeds 40K bytes.*

```
                              ANALYST FILE SPECIFICATION

        FILE DEFINITION FILE NAME:    CBASE.FIL
        DATA FILE NAME:               CBASE.INP
        DATA FILE DRIVE:              B
        DATA FILE DESCRIPTION:        CONVERTED CBASIC FILE
        NUMBER OF ITEMS:                4
        RECORD LENGTH                  20


                               RECORD SPECIFICATIONS

        ITEM NO   ITEM NAME                ITEM POSITION  ITEM LENGTH   ITEM TYPE

           1     STOCK NUMBER                   1             5          INTEGER
           2     TYPE                           6             4          INTEGER
           3     QUANTITY                      10             5          INTEGER
           4     BASE METAL                    15             3          ALPHA
```

Text continued from page 352:

been subtotaled, then all the NET G OR LS data totaled after each page. The results of mathematical operations appear only on the printed report and do not modify stored field data. To change stored data one record at a time, you use the edit function. To modify fields globally (all or selected fields of all records in the entire file) you can "extract" field data from the STOCK data file, process it, and deposit it in a new file. The new file is generated in the same manner as the STOCK illustration, but it is assigned a different file name. You can make logical selections (extractions) by choosing one of the following:

- RANGE—Does the field value fall within a range of alphanumeric or numeric values?
- MATCH—Does the field value equal the value you specify?
- NOT RANGE—Does the field value fall outside a range of values?
- NOT MATCH—Field data not equal.

In the case of the STOCK file, you can, for example, request Analyst to MATCH COMPANY to EAL within a DATE PURCHASED RANGE of 01/01/80 to 01/01/81 and in the COST/SHARE NOT RANGE from $15 to $1000. Because all these comparisons are true for the EAL stock in our example, the EAL stock will be selected. Using the same approach, you can then write this or any other selected stock(s) to a new file. Analyst lets you use as many as 10 selection screens in one command string. After selection, the stock's field data can be mathematically manipulated before it is deposited in the new file. You can use the same technique to select groups of records for display. With the CP/M command Control P (holding down the Control key and simultaneously depressing P), you can print selected records.

To assess Analyst's performance a second time, I used a file called CBASE, which contains 2000 records (see listing 3 for a program listing of the CBASE file specifications). Files generated by CBASIC can be transferred to Analyst data files and vice versa.

STOCK NUMBER contains random integers from 10,001 to 99,999. TYPE contains integers from 4000 to 8000, stepped by two (4000, 4002, etc.). QUANTITY has random integers from 20,000 to 30,000. BASE METAL is mixed alphanumeric data. Containing more than 40K bytes, this file is large enough to provide an indication of how this DBMS performs with files of moderate size, but the tests are not comprehensive enough to be considered benchmarks. I ran timing tests on a Dynabyte 8/2 microcomputer. Table 1 shows the results.

The times in table 1 show that Analyst is very fast for some functions. Single-record find and display times are outstanding. Program module load and run times are just acceptable but are long enough to mandate entering or retrieving "batch" data (a number of records at one time) to minimize the effect of the wait periods between different program functions.

Summary

Although load times for the program modules are slower than machine-language programs, this is not a

Analyst Program Modules	Time (in seconds)
Load Analyst until main menu appears (CP/M previously loaded)	35
Go from main menu to start of report printing	25
Go from main menu to data entry	15
Return to main menu from data entry	15
Enter 50 new CBASE records	As fast as you can type
Sort 2050-record CBASE on one field	130
Find single record by key search	3
Find single record by record	3
Search 2050-record file for logical selections	
If desired records at start of file	4
If desired records at end of file	300
Print a report	
Load Analyst to main menu	35
Select REPORT on menu until ready to print (plus actual print time; depends on speed of printer and size of report)	25
Return to main menu after printing	15

Table 1: *Timings of Analyst in use. Analyst was running on a Dynabyte 8/2 microcomputer. The data processed came from the CBASE file specified in listing 3. That file contains more than 40K bytes of data. These tests, while they give a rough idea of Analyst's performance, are not comprehensive enough to be considered benchmarks.*

limiting factor for many applications. The program can select and display or print records from the database very quickly and so compares favorably with DBMS programs that cost two to three times more than Analyst. Newcomers to computing will have no difficulty generating programs to perform these functions.

Designing formatted tabular reports with Analyst is tedious and, at first, complex.

Analyst's documentation is excellent, and anyone with a reasonable amount of programming experience will have little difficulty. Beginners, however, will need help.

A minor annoyance is Analyst's output of a formfeed (advancing the paper to the top of the next sheet) at the beginning of every printed report or program listing. (If I need to go to the top of a form I like to hit the formfeed, or two or three linefeeds, rather than have the program put what usually turns out to be a full blank sheet of paper between printed pages.) Another drawback is that mailing-list printouts may only be one column wide, which is inefficient if you plan to print many labels.

The report outputs are limited to five lines for one record. As a result, the program as presently designed will not readily print invoices, checks, or other report forms.

Structured Systems Group's Analyst and Qsort is one of the most reasonably priced CP/M packages on the market today. For many applications, it will be as satisfactory as DBMS programs that cost much more. If you're in the market for a DBMS, this one may meet your requirements. ■

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The Timex/Sinclair 1000

Billy Garrett
POB 18806
Greensboro, NC 27419-8806

Many BYTE readers own a personal computer, just as I do. And like many readers, I justify the cost of the computer by using it for word processing, mathematical programs, job-related applications, and even games. But if you're as addicted to computers as I am, you will eventually do something that you may never be able to explain—buy another one.

Sure, I could easily explain such a purchase if my old computer was too slow or unable to do the things that the new one could, but that's not the case at all. That excuse is reserved for some 16- or 32-bit processor that isn't on the market yet. The fact is I suddenly found myself buying a Timex/Sinclair 1000. And what's worse, I already own a Sinclair ZX80! Clearly, this was going to take some creative explaining.

At first, I thought I could convince people that I bought it for experimentation, but that argument is a little shaky. I concluded that the only way to justify the purchase was to write a review of it.

As most of you know, the Timex/Sinclair 1000 is essentially the same as the Sinclair ZX81. What you might not know is that all along Timex has been building the ZX81 for Sinclair. Under either name, the Sinclair people seem to have outdone themselves in designing it. It is similar to the older ZX80, and ZX80 users can upgrade their computers to the full capabilities of a T/S 1000.

In this review, I will first give you a general idea of what the unit is like. I'll then take you on a trip through the inner workings of the hardware. Finally, I'll try to compare the BASIC interpreter against some known standards. When I'm finished, I hope you'll see why the T/S 1000 fascinated me, and why I bought one.

General Characteristics

The T/S 1000 comes completely assembled and tested for $99.95. At one time, if you wanted to save $20 and spend a few hours assembling a computer, you could have ordered the Sinclair ZX81 kit. But Sinclair has now stopped selling the ZX81 and has allowed Timex an exclusive market in the United States. You can expect the new Sinclair Spectrum color computer to be handled in the same way. Sinclair will sell them exclusively for a while, and Timex will then take over the marketing.

The basic T/S 1000 package consists of the unit shown in photo 1 plus patch cords for a recorder, a connection wire and switch box for your TV, a manual, and a transformer. An optional 16K-byte RAM (random-access read/write memory) pack is also shown in photo 1.

The computer is easy to set up and use. Clear instructions show you what to do, and practically anyone should be able to set the computer up quickly. The accompanying manual is well written. Although it is not too simplistic, people with no knowledge of computers will be able to read it.

The T/S 1000 must of course be hooked up to a television set to be useful. The display, made up of black characters on a white background, has 24 lines with 32 characters per line. The two bottom lines, however, are used by the BASIC interpreter. Therefore, you really have only 22 lines. Within the character set are several graphics characters that are useful for games and charts. The cursor on the screen acts as a prompt and appears as a reverse video K, L, F, G, or S, which shows how the computer is going to interpret the next key entered. It will be interpreted as either a keyword, a letter (or number or symbol), a function, a graphics symbol, or a letter to correct a syntax error (if you make one, that is!).

The cassette interface is simple and reliable. You can name programs when you save them, and have the computer search through the tape and find a specific one, or just load the next one found.

The most restricting thing about the computer is the keyboard. I am used to typing, and it is impossible to



Photo 1: *The Timex/Sinclair 1000 computer with the optional 16K-byte RAM pack, which attaches to a connector on the right rear of the computer. The basic unit powers the RAM pack. (Photo courtesy of Timex Computer Corporation.)*

type on a keyboard as small as this one. Also, each key can signify up to four things (a letter, a BASIC keyword, a function, or a graphics symbol). Although the keys are well marked, it is hard to remember which key does what. Some of the keywords, like Delete and Edit, are in awkward places. The keys themselves provide almost no tactile feedback and are closely spaced; you constantly have to look at the screen to see if you have pressed the right key.

Also, although it's hard to use the keyboard as you would a typewriter, it is not very easy to use as a calculator either. Most calculators have a Function key that accesses a function written above certain keys. With a calculator, you just press the Function key and then the key you want. The Shift key on the T/S 1000 serves the same purpose, but you must hold it down while you press the key you want. This means you have to use two hands. It would be easier if the Shift key could be used as on a calculator.

T/S 1000 BASIC is fairly easy to use. BASIC keywords can be entered with just one keystroke, but that's the only way these keywords can be entered. Line numbers from 1 to 9999 can be used. Multiple statements per line are not allowed. Error codes and program lines start on the bottom two lines of the display and work their way up the screen. Because the error codes are displayed as numbers, you will have to look them up in the manual to see which error occurred.

A nice feature is that the names of most variables can be any length. LONGNAME and LONGNAME2 are different and distinct variables. The T/S 1000's string-handling capabilities are nonstandard, as will be explained later. All things considered though, T/S 1000 BASIC is powerful.

Finally, the T/S 1000 has a 90-day warranty, which should help most users if they find out that their computer is actually a lemon. Timex also offers a one-year extended warranty for $12. This offer is good only for people whose warranty hasn't run out, or those who have just had their unit in for repair. Timex even provides a computer club, open to all T/S 1000 owners, that will keep them up to date on any new developments, hardware and software products, and special offers. One last thing, because the T/S 1000 is being marketed everywhere, a good shopper can probably find it for a bit less than $99.95. I haven't even looked hard and I've seen it for $87.

The Insides: The Less, The Better

The T/S 1000 uses state-of-the-art circuitry. Only four ICs (integrated circuit chips) are inside the small enclosure, as is shown in photo 2. These four ICs, along with an IC voltage regulator; two transistors; several diodes, resistors, and capacitors; a video modulator; and the membrane keyboard, make up the entire unit. One

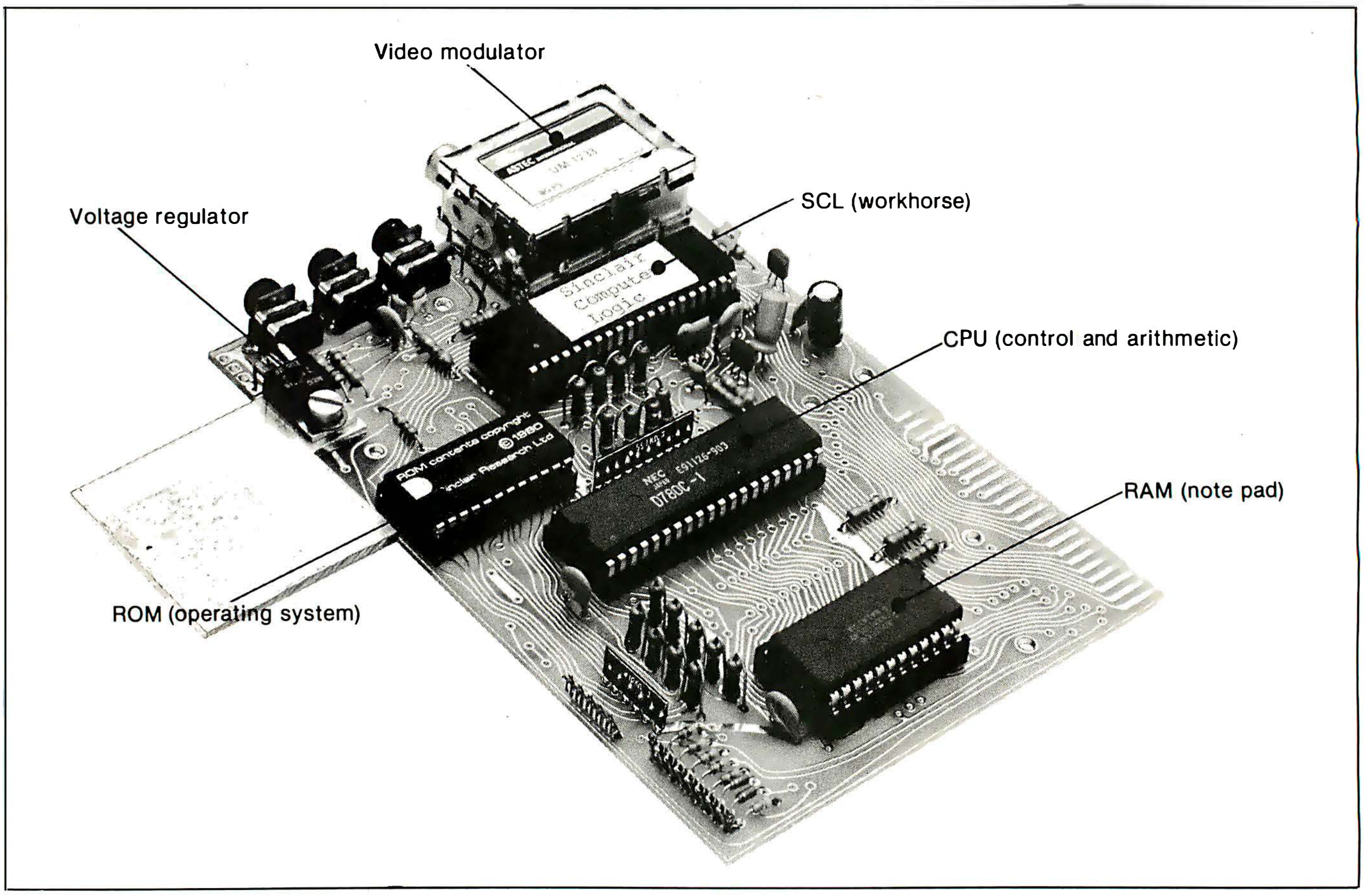


Photo 2: *The small circuit board inside the Timex/Sinclair 1000. Note that in this photo some of the chips have been put in backward so that you could read what's on top. The silver plate on the bottom left side is the heat sink. The connector in the right rear is for expansion. The three jacks on the left side are for power, tape in, and tape out. The two small connectors that are part of the right front of the board are where the keyboard is connected. The other parts are clearly labeled. (Photo courtesy of Timex Computer Corporation.)*

big change between the ZX80 and the T/S 1000 (ZX81) is a custom 40-pin IC made by Ferranti (a large British semiconductor manufacturer), which replaces 18 ICs that were in the ZX80 and adds additional logic circuitry. This chip is called the SCL (Sinclair Computer Logic). The new logic circuitry inside the SCL allows the T/S 1000 to display a picture continuously on the TV, even when the computer is executing a program. This is a big improvement over the older ZX80 that couldn't display a picture while executing a program; the screen would go blank every time a program was run or any time you pressed a key.

The Microace company sells a modification for the ZX80 that allows a ZX80 owner to have the equivalent of a T/S 1000. Unfortunately, although the additional logic board is small and contains only seven ICs, the board won't fit inside the ZX80's case. But if you really want the continuous display, the upgrade is only $29.95 from Microace (see table 1). It works fairly well, but the board is not made by Sinclair, and I had problems with it. Microace was prompt in responding to my request for help, but its response was that I must have assembled something wrong or that something wasn't working properly. The latter turned out to be the case. After I replaced a 74LS00 chip, the modification board worked fine.

The basic T/S 1000 unit comes with 2K bytes of static RAM (random-access read/write memory). This is the only difference between it and the Sinclair ZX81; the ZX81 had only 1K bytes. In either case, this is hardly enough to do any serious programming because the display shares this RAM with the program. A program that fills the TV screen will quickly run out of display room when the program is run. The BASIC interpreter uses 124 bytes of the RAM for its own internal processing, and the display can occupy a maximum of 727 bytes of memory. That leaves 173 bytes for a program in the ZX81 and 1197 bytes in the T/S 1000. Of course, because the display is not hard-mapped to one location in memory, it occupies only as much memory as it really requires.

In addition to the RAM, there is an 8K-byte ROM (read-only memory) chip in which the character generator for the display and the BASIC interpreter reside. The character generator occupies about 512 bytes of the ROM; the rest is used for the BASIC interpreter and the I/O (input/output) procedures.

The central processing unit not only has to execute the BASIC interpreter, but also must handle the TV display. This is accomplished through a clever arrangement. After each instruction is fetched from memory and executed, the display circuitry accesses the ROM and loads the bits

Information on the flicker-free board for the Sinclair ZX80:
Microace
1348 East Edinger
Santa Ana, CA 92705
(714) 547-2526

Monthly newsletter:
Syntax
The Harvard Group
RR 2, Box 457
Harvard, MA 01451
(617) 456-3661

Bimonthly magazine:
SYNC (Published by *Creative Computing*)
39 East Hanover Ave.
Morris Plains, NJ 07950
(201) 540-0445

Schematics, etc.:
Heuristics
25 Shute Path
Newton, MA 02159

Table 1: *The addresses of some companies that might be of interest to owners of the Timex/Sinclair 1000 or the Sinclair ZX81.*

At A Glance

Name
Timex/Sinclair 1000

Manufacturer
Timex Computer Corporation
POB 2655
Waterbury, CT 06725
(203) 574-3331

Price
$99.95

Dimensions
6⅝ inches wide by 7 inches long by 1½ inches high (16.8 by 17.7 by 3.9 cm)

Processor
Z80A, 8-bit, 3.25-MHz clock frequency

Memory
2K-byte RAM standard; 16K-byte RAM optional ($49.95); 8K-byte ROM included

Mass Storage
Cassette I/O, only program storage and loading; no BASIC controlled I/O

Display Used
Standard television set (RF modulator included); 32 black-and-white characters per line, 24 lines; the user cannot use the bottom two lines, which are reserved for the BASIC interpreter's use

Other Features
Membrane keyboard; built-in modulator (for TV); includes all cables and transformer

Documentation
154 pages, spiral-bound manual

Software Included
BASIC in ROM

Software Options
Various application programs available on cassette

Hardware Options
16K-byte RAM ($49.95); electrostatic printer ($99.95); telephone modem ($99.95)

Audience
Students, businesspeople, or anyone else interested in learning about computers for a very low cost

of the character to be displayed on the screen. The bits are then serialized and sent to the TV with that custom-made 40-pin logic chip. The processor must coordinate this activity, which requires a lot of its time. Because of this, the T/S 1000 offers two modes of operation available to the user: SLOW and FAST. When the unit is turned on or when a NEW command is executed, the display enters the SLOW mode. This means that the display is on continuously, even during the execution of a program. If you do not need to have the display on all the time, you can use the FAST mode. In this mode, the display is on only when a program has finished running or when the unit is awaiting input. The manual states that the difference in execution speed of the two modes is a factor of about four, but in every test that I have run the difference is almost a factor of six. I haven't run any benchmark programs, but even in the FAST mode this is about the slowest BASIC interpreter I have ever used.

The design of the circuit board is interesting. The current revision has provisions for different types of RAM chips to be plugged into the board. The ZX81s came with two 2114 chips, for a total of 1K bytes. The T/S 1000 uses a single 2K-byte RAM chip. When you need more memory, you can buy the 16K-byte RAM pack for $49.95.

One of the most exciting things about the T/S 1000 circuit is that the ROM socket was designed so that larger-capacity ROM chips could be plugged in. If you are familiar with the standard ROM pin arrangements, you know that with a 24-pin package the maximum size of a standard, nonmultiplexed, byte-wide ROM chip is 8K bytes. Well, Sinclair has already wired the board for a 28-pin package, which would allow a 16K-byte ROM chip. Although Sinclair has not commented on the possibility of a 16K-byte ROM for the T/S 1000 or its successor, you can be sure that someone is thinking about it. A 16K-byte ROM would increase the capabilities of the T/S 1000 greatly, but it may be a while before we hear anything about that possibility.

Unlike the keyboard in the ZX80, the T/S 1000 keyboard is not an integral part of the main circuit board. It thus can be easily replaced, and Sinclair could design a more conventional "full-travel" keyboard and offer it as a replacement. I, for one, would like a better keyboard; and with more than 200,000 T/S 1000s and ZX81s in existence, Sinclair stands to make lots of money on any good accessories. Current plans, however, include only a printer and a modem.

T/S 1000 BASIC

The new 8K-byte BASIC included in the T/S 1000 is remarkably powerful for being just 7.5K bytes long (remember that the character generator occupies 512 bytes of ROM). Tables 2 through 5 list all the available commands, while table 6 includes some commands that are common for BASIC but not implemented in this version.

Function	Type of Operand (x)	Result
ABS	number	Absolute magnitude
ACS	number (−1 <= x <= 1)	Arc cosine in radians
AND	binary operation AND	A AND B = A (if B <> 0) = 0 (if B = 0)
ASN	number (−1 <= x <= 1)	Arc sine in radians
ATN	number	Arc tangent in radians
CHR$	number (0 to 255)	The character associated with a given code
CODE	string	The code of the first character in string (or 0 if x is the empty string)
COS	number (in radians)	Cosine
EXP	number	Exponential function (e^x)
INKEY$	none	Scans the keyboard once and returns the character if a key is pressed or returns the empty string if no key is pressed
INT	number	Integer part (always rounds down)
LEN	string	Length of string
LN	number (x >= 0)	Natural logarithm
NOT	number	NOT x = 0 (if x <> 0) = 1 (if x = 0)
OR	binary operation	A OR B = 1 (if B <> 0) = A (if B = 0)
PEEK	number (0 <= x <= 65535)	The value of the byte in memory whose address is x
PI	none	3.14159265
RND	none	The next number in a pseudorandom sequence of 65,535 numbers
SGN	number	Sign of the number (−1, 0, 1)
SIN	number (in radians)	Sine
SQR	number (x => 0)	Square root of x
STR$	number	The number x returned as a string
TAN	number (in radians)	Tangent
USR	number (0 =< x =< 65535)	Calls the machine-code subroutine whose start address is x; on return, the result is the contents of the BC register pair
VAL	string	Evaluates the string as a numerical expression
"−"	number	Negation

Table 2: *Some of the functions found in T/S 1000 BASIC.*

Symbol	Operation
+	addition
−	subtraction
*	multiplication
/	division
**	raising to a power
=	equals
>	greater than
<	less than
<=	less than or equal
>=	greater than or equal
<>	not equal

Table 3: *The binary operations included in T/S 1000 BASIC.*

The manual does a good job explaining the language, and it is interesting to note how this manual was developed. First, there was a British version for the Sinclair ZX81, which naturally tended to use British colloquial expressions. That manual was much more interesting than the subsequent American Sinclair or Timex versions, although all are equally informative. For example, at one point the author of the British version refers to photo 2 and writes, "As you can see, everything has a three letter abbreviation (TLA)." I thought this was a rather amusing comment, and most of the examples are humorous also. This is a good way of making the novice feel a little more relaxed while he or she is trying to learn what all those darn abbreviations are for. Unfortunately, the humor was carefully excised from the American manuals, even though the manuals are exactly the same in content and number of examples. Any one of these manuals, however, is an excellent introduction to BASIC. The many examples and exercises should make it easy and fun to learn.

The manual is mostly devoted to BASIC, but it also covers some rather intricate details of the BASIC interpreter. One interesting point about the manual is that it not only tells you which bytes in memory are used, but also what they are used for. This documentation is helpful if you are going to write any machine-language routines. This is a useful piece of information for them to include, something that many other companies can't or won't do because of their agreements with the authors of their BASIC interpreter.

T/S 1000 BASIC does differ substantially from the Microsoft variety that many of us are acquainted with. This BASIC was apparently written by a group of Cambridge (England) mathematicians. The biggest improvement that this 8K-byte ROM has over the 4K-byte ROM that was standard in the ZX80 is that this version handles floating-point numbers. Also included are the usual functions, such as SIN, COS, and LN, that are standard with most BASICs. This version, however, suffers from one really bad problem—string irregularities.

Most people who have used BASIC are accustomed to string functions like LEFT$, RIGHT$, MID$, or other functions like these. For example, LEFT$(NAME$) allows you to examine the first letter of a name. But the T/S 1000 uses what they call *slicing* notation. A few examples will clarify this immediately:

```
LET A$="SINCLAIR"

PRINT A$(1 TO 8)
would print: SINCLAIR

PRINT A$(3 TO )
would print: NCLAIR

PRINT A$(1 TO 1)+"ILLY"
would print: SILLY
```

Command	Function
AT	Used in a PRINT statement to specify the position of the cursor.
CLEAR	Deletes all variables, freeing the space they occupied.
CLS	Clears the display file.
CONT	Continues if the program has any executable lines left.
COPY	Copies the contents of the screen to the printer. The COPY command will not change the display.
DIM	Reserves enough memory for an array of the given dimension and deletes any arrays already set up with that name.
FAST	Increases execution speed by turning the display off when a program is running.
FOR *a* = *x* TO *y* STEP *z*	Executes a FOR/NEXT loop and deletes any other variable that will conflict with the loop variable *a*; will count from *x* to *y* by increments of *z*.
GOSUB	Pushes the line number of the GOSUB statement on a stack and calls the BASIC code starting at that line number.
GOTO	Jumps to the specified line or the next one after that number.
IF *exp* THEN *s*	If *exp* is true, then *s* is executed, and *s* must be a statement.
INPUT *v*	Stops and waits for the user to input an expression.
LET	The variable assignment statement.
LIST	Lists the program on the screen.
LLIST	Same as LIST, except that it goes to the printer.
LOAD *f*	Loads a program called *f*. Loads the first program if *f* is null.
LPRINT	Same as print, except routed to the printer.
NEW	Deletes any program lines and variables, setting aside all memory up to the top of available RAM or to the system variable RAMTOP, whichever is lower. Also enters the SLOW mode.
NEXT	Ends a FOR loop.
PAUSE *n*	Stops computing and displays the display file for *n* frames (at 60 frames per second) or until a key is pressed.
PLOT *x,y*	Blacks in pixel *x,y* and moves the print position one space to the right of that pixel (resolution: 64 by 44).
POKE *m,n*	Replaces byte at location *m* in memory with byte *n*.
PRINT	Prints whatever you specify in the print statement on the screen.
RAND	Seeds the random-number generator.
REM	Makes that line a comment statement, which is ignored by the computer. This is useful for placing machine-language subroutines in REM statements since they don't move about in memory.
RETURN	Pops the number from the GOSUB stack and returns to the line after it.
RUN	Runs a program beginning with the line you specify, or the beginning if you don't.
SAVE	Saves the program, variables, and other system information on tape.
SCROLL	Scrolls the display file up one line, replacing the bottom line with a NEWLINE character.
SLOW	Leaves the display on all the time, even during the program execution. The computer powers up in this mode and returns to the SLOW mode whenever a NEW command is executed.
TAB	Prints at this position. Must be used in a PRINT statement.
UNPLOT *x,y*	Whitens out the pixel *x,y*.

Table 4: *T/S 1000 BASIC commands.*

As you can see, the slicing notation takes the number of characters that you specify in the range given in parentheses and prints them. If the first or last number is left off, it assumes the beginning or the end of the string respectively. This is not at all hard to get used to, but it is nonstandard.

One really good feature is that the strings can be any length, but string names are limited to one letter followed by the string symbol "$". You can get more than 26 strings, though, by dimensioning them. When you do so, however, you must specify how many characters are going to be in each string. For example, if you type DIM X$(2,20), you get two strings each with a length of 20 characters. This too is nonstandard for BASIC.

One bad point about the T/S 1000 is its lack of compatibility with the old ZX80 programs (written using the 4K-byte ROM). The programs will run, of course, but the user must make some minor modifications, type them in again, and save them on cassette tape.

As a cassette-based machine, the T/S 1000 has certain limitations. For example, this BASIC does not allow you to save values of some of the variables without saving all the variables and the program too. In fact, the entire state of the machine is saved when you execute a SAVE command, so that you can get right back where you were after loading the program and typing CONT. This limitation of the SAVE command makes the T/S 1000 difficult to use with programs that require saving data, but it is convenient for the novice. One limitation is that the SAVE command must not be nested inside a GOSUB. Another limitation is that cassette I/O is slow, and the T/S 1000 is not a likely candidate for a floppy-disk interface mainly because of the expense. Certainly, a floppy disk could increase the capabilities of the T/S 1000, but who would buy a controller and disk for $400 when the basic computer was only $100? But we don't know what Clive Sinclair will be up to next . . . a microfloppy for $100?

The actual process of entering a program is easy for the novice but exasperating for the experienced computer user, because BASIC keywords can be entered only by using a one-key abbreviation. If you want to enter RUN, you just press the R key and then the NEWLINE key, instead of pressing R, U, N, and then NEWLINE. It will take a while to learn the location of each keyword. Some are in awkward places. The RUBOUT (delete) key is a

Command	Function
EDIT	Edits the current line.
Up arrow	Moves the current line back one.
Down arrow	Moves the current line forward.
Right arrow	Moves the cursor forward.
Left arrow	Moves the cursor backward.
BREAK	Stops execution of a program.
NEWLINE	Terminates every line.
RUBOUT	Deletes the last character or keyword.
GRAPHICS	The next keys pressed will be interpreted as graphics symbols.
FUNCTION	The next key pressed will be the function written below the key.

Table 5: *Editing commands found in T/S 1000 BASIC.*

AUTO	LINEINPUT
DATA	MEM
DEFSTR	MID$
DEFINT	ON ERROR
DEFSNG	ON x GOTO
DEFDBL	PRINT # (to cassette)
ELSE	READ
FNDEF	RESTORE
INPUT#	RIGHT$
LEFT$	USING

Table 6: *Some common BASIC commands missing from T/S 1000 BASIC.*

shifted 0. Frequently, I forget to press the Shift key before I press the 0 key.

Like the ZX80, the T/S 1000 has 40 keys. The keyboard can be accessed in a BASIC program either through an INPUT statement or through the INKEY$ function.

One more nonstandard feature is that the character code set is totally unique to the T/S 1000; it's not ASCII (American Standard Code for Information Interchange). For example, in ASCII the letter "A" is represented by 41 (hexadecimal); the T/S 1000 refers to the same letter as 26 (hexadecimal). Making this unit into a terminal would take a little hardware and a considerable programming effort.

If you want more information on the T/S 1000, ZX80/ZX81, or the Microace computer (no longer made), see table 1 for addresses of these companies. Also, two other articles on these computers have appeared in BYTE. They are "The MicroAce Computer" by Delmar Searls, April 1981, page 46, and "The Sinclair Research ZX80" by John C. McCallum, January 1981, page 94.

Conclusions

Although T/S 1000 BASIC is different, it is powerful for such a small, low-priced computer. I think that anyone who buys it won't be disappointed. It does, however, suffer from its lack of standardization and omission of powerful BASIC functions.

The TV interface works very well, and the display can easily be read on almost any TV.

The membrane keyboard makes the computer difficult to work with for long periods of time.

The cassette is easy to use for simple program storage, but it is limited and will hamper many application programs.

The major use for this computer will probably be for learning about BASIC or computers in general. The computer itself has limited expansion capabilities, and the keyboard is too small and cramped for any serious work. ■

Vector Graphics for the TRS-80

Incorporate machine-language graphics into your BASIC programs.

Dan Rollins
134 Olive St.
Glendale, CA 91206

Radio Shack has given the TRS-80 Model I and III user a flexible alternative to memory-gobbling high-resolution graphics and functionally limited low-resolution graphics—namely, the SET and RESET graphics commands. Unfortunately, due to the size limitations of the BASIC ROM (read-only memory), Radio Shack was unable to include any vector-graphics functions. BASIC has no command for drawing lines on the video monitor.

Radio Shack has, however, provided excellent tools for interfacing machine-language code to a BASIC program—the VARPTR and USR functions. Using these tools, it is possible to program graphics with fast, machine-language software while enjoying all the benefits of BASIC programming.

KWIKLINE is a fast line-drawing program (see listing 1). Using the VARPTR and USR machine-language functions as "hooks," it draws lines composed of either pixels (picture elements) or ASCII (American Standard Code for Information Interchange) characters. This article describes how to place a machine-language routine in a BASIC program line, how KWIKLINE works, and how to use vector graphics with BASIC.

Machine Language in a BASIC String

To summarize the operation of these functions, a USR function will execute a previously prepared machine-language routine, passing the 2-byte expression as the single argument. The VARPTR function returns an address from BASIC's variables table. This address may be used as a pointer to the actual storage location of the variable.

Using the VARPTR and USR machine-language functions as "hooks," it draws lines composed of pixels or ASCII characters.

Variables created during program execution, e.g., A$ in the following line:

```
100 A$ = CHR$(191)+CHR$(128)
```

are stored in high memory within the area reserved by the CLEAR command. But string variables such as A$ in the line

```
100 A$ = "THIS IS A LITERAL"
```

remain in program memory. Using the VARPTR function with A$ would return the address value of the character on the program line directly after the first quotation mark.

The *Level II BASIC Reference Manual* explains how to concatenate a string variable from DATA line values and use the VARPTR value of the string as the starting address of the USR routine. Going one step further, it is possible to create a "dummy" string on a program line, find the location of its first byte using VARPTR, use READ and POKE to place values into the string, and use this string variable as a machine-language USR routine. The DATA lines containing the Z80 op-code values and the lines that contain the POKE commands may then be

Text continued on page 375

Listing 1: *Assembly-language version of the KWIKLINE program.*

```
                 ;                  KWIKLINE
                 ;               by  Dan Rollins
                 ;                  8/20/81
                 ;
                 ;Relocatable line drawing routine for TRS-80 MOD. 1 & 3
                 ;Suitable for placement in a string variable on a BASIC
                 ;program line.
                 ;Draws a line (or series of lines) of
                 ;
                 ;           SET or RESET pixels
                 ;                  OR
                 ;       any displayable CHARACTER
                 ;
                 ;Routine requires 6 arguments per line :
                 ;             X1      = starting X ordinate
                 ;             Y1      = starting Y ordinate
                 ;             X2      = ending X ordinate
                 ;             Y2      = ending Y ordinate
                 ;             SR      = SET/RESET/CHARACTER  flag
                 ;                         1     = SET
                 ;                         0     = RESET
                 ;                         else  = CHARACTER (2-255)
                 ;             EX      = extension flag
                 ;                         "&"    = another line follows
                 ;                         else   = this is last line
                 ;
                 ;From BASIC, compile a string variable consisting of
                 ;a series of bytes in the above order :
                 ;
                 ;A$ = CHR$(X1) + CHR$(Y1) + CHR$(X2) + CHR$(Y2)
                 ;    + CHR$(SR) + CHR$(EX)
                 ;
                 ;Draw the line via :
                 ;
                 ;        UU = USR(VARPTR(A$))
                 ;
                 ;*** NOTE : This program does not check for parameter
                 ;***        errors, but will affect only video memory.
                 ;***        Bad parameters may draw spurious lines
                 ;***        on the screen.
                 ;*** When using CHARACTER mode :
                 ;***     X1 and X2 must be >= 0 and <= 63
                 ;***     Y1 and Y2 must be >= 0 and <= 15
                 ;*** When using SET/RESET mode :
                 ;***     X1 and X2 must be >= 0 and <= 127
                 ;***     Y1 and Y2 must be >= 0 and <= 47
                 ;
                 ;<><><><><><><><><><><><><><><><><><><><><><><><><><><>
                 ;
0001             STARTX  EQU    +1       ;set up offsets for IX index
0002             STARTY  EQU    +2       ; pointer so that no zero will
0003             ENDX    EQU    +3       ; occur in assembled code.
0004             ENDY    EQU    +4
0005             SRBYTE  EQU    +5
0006             EXTCHR  EQU    +6
0001             STEP1   EQU    +1       ;these variables use the string
0002             STEP2   EQU    +2       ; memory occupied by the
0003             ALTST1  EQU    +3       ; argument parameters.
0004             ALTST2  EQU    +4
                 ;
                 ;<><><><><><><><><><><><><><><><><><><><><><><><><><><>
                 ;
0000                     ORG    0              ;position independent code
0000 CD7F0A              CALL   0A7FH    ;Get HL = VARPTR( parameter$ )
0003 23                  INC    HL       ;get past string length byte
0004 5E                  LD     E,(HL)
0005 23                  INC    HL
0006 56                  LD     D,(HL)
0007 1B                  DEC    DE       ;so offsets won't be zero
0008 D5                  PUSH   DE
0009 DDE1                POP    IX       ;IX points to arguments
000B DD6603      NEXTLN  LD     H,(IX+ENDX)
000E DD6E04              LD     L,(IX+ENDY)
0011 E5                  PUSH   HL       ;save these on stack till exit
                 ;
0012 DD5601              LD     D,(IX+STARTX)
0015 DD5E02              LD     E,(IX+STARTY)
0018 D5                  PUSH   DE
                 ;
                 ;This code initializes the variables used by the
                 ;DDA routine.  Offsets are calculated for each step
                 ;from point to point.
0019 7C                  LD     A,H
001A 2601                LD     H,1                ;A1 = 1
001C 92                  SUB    D                  ;DIST1 = X2-X1
001D 3004                JR     NC,D1OK            ;if DIST1 >= 0 then skip
001F 26FF                LD     H,0FFH             ;  else A1 = -1
0021 ED44                NEG                       ;       DIST1 = - DIST1
0023 47          D1OK    LD     B,A
                 ;
0024 7D                  LD     A,L
0025 2E01                LD     L,1                ;S1 = 1
0027 93                  SUB    E                  ;DIST2 = Y2-Y1
0028 3004                JR     NC,D2OK            ;if DIST2 >= 0 then skip
002A 2EFF                LD     L,0FFH             ;  else S2 = -1
002C ED44                NEG                       ;       DIST2 = - DIST2
002E 4F          D2OK    LD     C,A
002F 11FFFF              LD     DE,-1
0032 13                  INC    DE       ;res. D= A2= 0, res. E= S1= 0
0033 B8                  CP     B        ;if DIST1 >= DIST2 then skip
0034 3803                JR     C,AXISOK
0036 48                  LD     C,B      ;  else exchange D1 with D2
0037 47                  LD     B,A
0038 EB                  EX     DE,HL    ;       exchange A1 with S1
                                         ;       exchange A2 with S2
```

Listing 1 continued:

```
                   ;
0039 DD7401        AXISOK  LD    (IX+STEP1),H     ;save step values
003C DD7302                LD    (IX+STEP2),E
003F DD7203                LD    (IX+ALTST1),D    ; and alternate steps
0042 DD7504                LD    (IX+ALTST2),L    ;  at string location
0045 68                    LD    L,B
0046 61                    LD    H,C
0047 48                    LD    C,B              ;res. B is long axis
0048 CB39                  SRL   C                ;res. C is B/2
004A 04                    INC   B                ;adjust for DJNZ op code
                   ;
004B D1                    POP   DE
004C D5                    PUSH  DE               ;set X1, Y1
                   ;
                   ;
                   ;Displacements and offsets have been calculated :
                   ;       H = DIST1              L = DIST2
                   ;       D = X1  (STARTX)       E = Y1  (ENDX)
                   ;       C = step size (number of X's before Y changes)
                   ;       B = loop counter (length of longest axis)
                   ;      IX => S1, S2, A1, A2    (steps & alternate steps)
                   ;
                   ;Now loop through, plotting each line.
                   ;                                         ************
004D E5            NEXTPL  PUSH  HL      ;save main registers          *
004E C5                    PUSH  BC      ;                             *
                   ;                                                   *
004F DD7E05                LD    A,(IX+SRBYTE)  ;if 5th argument is    *
0052 FE02                  CP    2              ;1 or 0, mode is PIXEL
0054 381A                  JR    C,PXMODE
                   ;
                   ;**************************************************
                   ;*      This section determines a screen address   *
                   ;* at entry : D = column position (0-63)         *
                   ;*            E = screen row       (0-15)        *
                   ;* at exit : HL => video memory at requested byte *
                   ;*      destroys HL and BC registers              *
                   ;**************************************************
                   ;
0056 63            CHMODE  LD    H,E            ;  else mode is CHARACTER
0057 6A                    LD    L,D            ;  set row and column
0058 CB25                  SLA   L
005A CB25                  SLA   L              ;column = column * 4
005C CB2C                  SRA   H
005E CB1D                  RR    L
0060 CB2C                  SRA   H
0062 CB1D                  RR    L              ;HL = HL/4
0064 47                    LD    B,A            ;save CHARACTER
0065 7C                    LD    A,H
0066 E603                  AND   3              ;Keep address on screen
0068 F63C                  OR    3CH
006A 67                    LD    H,A
006B 78                    LD    A,B            ;restore CHARACTER
006C 1837                  JR    SVBYTE         ;store the CHARACTER ars.
                   ;
                   ;
                   ;-=-=-=-=-=-=-=-=-=-=-         ;this is the "bridge"
006E 189B          JUMPER  JR    NEXTLN         ; which keeps KWIKLINE
                   ;-=-=-=-=-=-=-=-=-=-=-         ;   relocatable
                   ;
                   ;
                   ;*****************************************************
                   ;* This is a relocatable SET/RESET routine :         *
                   ;* At entry : D = X  (0-127)                         *
                   ;*            E = Y  (0-47)                          *
                   ;*  (IX+SRBYTE) = SET/RESET code (0 = RESET, 1 = SET)*
                   ;*  destroys HL, BC, AF registers                    *
                   ;*****************************************************
                   ;
0070 26FF          PXMODE  LD    H,0FFH
0072 7B                    LD    A,E       ;set Y ordinate
0073 24            DIV3    INC   H         ;divide Y value by 3
0074 D603                  SUB   3         ;leaving quotient in H res.
0076 30FB                  JR    NC,DIV3   ;   H is 0-15
0078 C603                  ADD   A,3       ;and remainder in B res.
007A 47                    LD    B,A       ;   B is 0-2
007B 6A                    LD    L,D       ;set current X ordinate
007C CB25                  SLA   L         ;L = X * 2
007E CB2C                  SRA   H
0080 CB1D                  RR    L
0082 CB2C                  SRA   H         ;Divide HL by 4, leaving
0084 CB1D                  RR    L         ;remainder in carry flag
0086 CB10                  RL    B         ;determine pixel position by
0088 04                    INC   B         ;B =DIV3 rmdr * 2 + DIV4 rmdr + 1
0089 7C                    LD    A,H
008A E603                  AND   3                  ;Keep address on screen
008C F63C                  OR    3CH                ;HL points to requested
008E 67                    LD    H,A                ;screen position address
008F AF                    XOR   A
0090 37                    SCF
0091 8F            GETBIT  ADC   A,A       ;determine pixel value by
0092 10FD                  DJNZ  GETBIT    ; taking 2 to the Bth power
                   ;
0094 CB7E                  BIT   7,(HL)             ;check if currently
0096 2002                  JR    NZ,GFXOK           ; graphics, so if so
0098 3680                  LD    (HL),80H           ;   else clear the byte
009A DDCB0546      GFXOK   BIT   0,(IX+SRBYTE)      ;if SET/RESET flag is 0
009E 2803                  JR    Z,RESET            ;  then skip .... else
00A0 B6            SET,    OR    (HL)               ;add a bit to screen byte
00A1 1802                  JR    SVBYTE
00A3 2F            RESET   CPL
00A4 A6                    AND   (HL)               ;mask this bit from byte
00A5 77            SVBYTE  LD    (HL),A             ;save the byte on screen
                   ;
00A6 C1            PLEXIT  POP   BC
00A7 E1                    POP   HL        ;restore main registers
                   ;
                   ;
```

Listing 1 continued on page 374

Listing 1 continued:

```
                 02230 ;**************************************************
                 02240 ;*     Digital Differential Analyzer routine      *
                 02250 ;* adds displacements to current plot coordinates *
                 02260 ;**************************************************
                 02270 ;
00A8  7A         02280 DDA      LD      A,D
00A9  DD8601     02290          ADD     A,(IX+STEP1)
00AC  57         02300          LD      D,A             ;X1 = X1 + step X
00AD  7B         02310          LD      A,E
00AE  DD8602     02320          ADD     A,(IX+STEP2)
00B1  5F         02330          LD      E,A             ;Y1 = Y1 + step Y
00B2  79         02340          LD      A,C
00B3  84         02350          ADD     A,H             ;adjust step check
00B4  4F         02360          LD      C,A
00B5  BD         02370          CP      L               ;if step check > DIST1
00B6  380C       02380          JR      C,NEXT          ; then skip
00B8  95         02390          SUB     L               ; else adjust step check
00B9  4F         02400          LD      C,A
00BA  7A         02410          LD      A,D
00BB  DD8603     02420          ADD     A,(IX+ALTST1)   ;add alternate steps
00BE  57         02430          LD      D,A             ; to X1
00BF  7B         02440          LD      A,E
00C0  DD8604     02450          ADD     A,(IX+ALTST2)
00C3  5F         02460          LD      E,A             ;    and Y1            *
                 02470 ;                                                        *
00C4  1087       02480 NEXT     DJNZ    NEXTPL          ;loop till finished    *
                 02490                                  ; with current line.   *
                 02500 ;                                             ***********
                 02510 ;
00C6  D1         02520          POP     DE
00C7  DD7201     02530          LD      (IX+STARTX),D   ;restore arguments to
00CA  DD7302     02540          LD      (IX+STARTY),E   ; avoid having to
00CD  E1         02550          POP     HL              ;    redefine them
00CE  DD7403     02560          LD      (IX+ENDX),H
00D1  DD7504     02570          LD      (IX+ENDY),L
00D4  DD7E06     02580          LD      A,(IX+EXTCHR)   ;if 6th argument is
00D7  FE26       02590          CP      '&'             ; not "&" return to BASIC
00D9  C0         02600          RET     NZ
00DA  110601     02610          LD      DE,0106H
00DD  15         02620          DEC     D               ; else point to next
00DE  DD19       02630          ADD     IX,DE           ; set of line parameters
00E0  188C       02640          JR      JUMPER          ; and loop to NEXTLN via
                 02650                                  ; JUMPER "bridge"
0000             02660          END
00000 TOTAL ERRORS

ALTST1 0003 00670   01180 02420
ALTST2 0004 00680   01190 02450
AXISOK 0039 01160   01100
CHMODE 0056 01540
DIOK   0023 00980   00950
D2OK   002E 01060   01030
DDA    00A8 02280
DIV3   0073 01860   01880
ENDX   0003 00610   00810 02560
ENDY   0004 00620   00820 02570
EXTCHR 0006 00640   02580
GETBIT 0091 02050   02060
GFXOK  009A 02110   02090
JUMPER 006E 01720   02640
NEXT   00C4 02480   02380
NEXTLN 0008 00810   01720
NEXTPL 004D 01390   02480
PLEXIT 00A6 02190
PXMODE 0070 01840   01440
RESET  00A3 02150   02120
SET    00A0 02130
SRBYTE 0005 00630   01420 02110
STARTX 0001 00590   00850 02530
STARTY 0002 00600   00860 02540
STEP1  0001 00650   01160 02290
STEP2  0002 00660   01170 02320
SVBYTE 00A5 02170   01680 02140
```

Listing 2: *BASIC-language version of the KWIKLINE program. The Z80 op codes from listing 1 are incorporated into the DATA statements in lines 1000-1140. Once line 20 has been packed with these op codes, you can save lines 10-50 and use them as a kernel around which to build your own program. Lines 2000-2090 are a simple test of the KWIKLINE program.*

```
5 '                         KWIKLINE
      machine language video line drawing program
                      by DAN ROLLINS
                          8/29/81

6 '
   This program POKEs the machine code into the dummy
   string (line 20) for use as a USR routine.  After a
   successful RUN, RUN again to test the code.

10 CLEAR 2000
20 LN$="----------------225 OR MORE DASHES--------------------
---------------------------------------------------------------
---------------------------------------------------------------
--------------------------------------------"
30 V=VARPTR(LN$)
40 POKE 16526,PEEK(V+1) :POKE 16527,PEEK(V+2) '* USR ENTRY
50 'DISK users erase to here > DEFUSR0=PEEK(V+1)+PEEK(V+2)*256
60 ADDR=PEEK(V+1)+PEEK(V+2)*256
70 CLS :PRINT@ 975,"CODE IS BEING POKED INTO LN$"; :PRINT@ 0,;
80 READ A$ :IF A$="END" THEN 150
90     B$=LEFT$(A$,1) :C$=RIGHT$(A$,1)
100    M=ASC(B$)-48+(B$>"9")*7 :L=ASC(C$)-48+(C$>"9")*7
110    CS=CS+M+L                          '* calculate checksum
120    PRINT A$;"  ";                     '* display each byte
```

Listing 2 continued on page 375

Listing 2 continued:

```
130      POKE ADDR,M*16+L :ADDR=ADDR+1
140 GOTO 80
150 IF CS = 3217 THEN PRINT "RUN WAS SUCCESSFUL    ";
      ELSE PRINT "** BAD DATA **" :STOP
160
    DELETE 60-1140        '** Kill all unnecessary lines **
999 '
    The hexadecimal format of these codes allows for entry
    via SUPERZAP or other disk or memory monitor.

1000 DATA CD,7F,0A,23,5E,23,56,1B,D5,DD,E1,DD,66,03,DD,6E
1010 DATA 04,E5,DD,56,01,DD,5E,02,D5,7C,26,01,92,30,04,26
1020 DATA FF,ED,44,47,7D,2E,01,93,30,04,2E,FF,ED,44,4F,11
1030 DATA FF,FF,13,B8,38,03,48,47,EB,DD,74,01,DD,73,02,DD
1035 '
1040 DATA 72,03,DD,75,04,68,61,48,CB,39,04,D1,D5,E5,C5,DD
1050 DATA 7E,05,FE,02,38,1A,63,6A,CB,25,CB,25,CB,2C,CB,1D
1060 DATA CB,2C,CB,1D,47,7C,E6,03,F6,3C,67,78,18,37,18,9B
1070 DATA 26,FF,7B,24,D6,03,30,FB,C6,03,47,6A,CB,25,CB,2C
1075 '
1080 DATA CB,1D,CB,2C,CB,1D,CB,10,04,7C,E6,03,F6,3C,67,AF
1090 DATA 37,8F,10,FD,CB,7E,20,02,36,80,DD,CB,05,46,28,03
1100 DATA B6,18,02,2F,A6,77,C1,E1,7A,DD,86,01,57,7B,DD,86
1110 DATA 02,5F,79,84,4F,BD,38,0C,95,4F,7A,DD,86,03,57,7B
1115 '
1120 DATA DD,86,04,5F,10,87,D1,DD,72,01,DD,73,02,E1,DD,74
1130 DATA 03,DD,75,04,DD,7E,06,FE,26,C0,11,06,01,15,DD,19
1140 DATA 18,8C,END
1999 '
      This is a simple test of KWIKLINE

2000 CLS
2010 INPUT "STARTING POINT (X1,Y1) ";X1,Y1
2020 INPUT "ENDING POINT (X2,Y2) ";X2,Y2
2030 INPUT "SET, RESET, OR CHARACTER MODE (S,R,C) ";M$
2040 IF M$="C" THEN INPUT "CHARACTER VALUE (ASCII) ";C
2050 IF M$="S" THEN C = 1
2060 IF M$="R" THEN C = 0
2070 A$=CHR$(X1)+CHR$(Y1)+CHR$(X2)+CHR$(Y2)+ CHR$(C) +"."
2080 UU=USR(VARPTR(A$))            '* draw the line
2090 GOTO 2010
```

deleted from the program—leaving only the machine-language code in a BASIC program line. The advantages of this "packing" of the code directly within a BASIC program are:

1. The machine-language code is saved and loaded efficiently with your program.
2. High memory need not be reserved at power-up.
3. Since the location of the string will not change, the USR-routine entry point doesn't need to be redefined.
4. The routine will not interfere with other machine-language programs, such as keyboard-debounce routines or printer drivers.
5. The format is compatible with DOS (disk operating system) and BASIC for both Models I and III of any size memory.

The limitations of this format are mainly those encountered by the routine's original programmer. The program must:

- be fully relocatable, using no absolute jumps or calls to locations within the program
- contain no bytes with values of 00 or 22 hexadecimal, as these are BASIC line and string delimiters
- use no look-up tables within the program—the table's starting point will vary with the routine's location
- be less than 241 bytes in length—the size of BASIC's program-line input buffer

List a program line containing such a packed string, and you'll see an odd collection of BASIC tokens and printing control characters. It will look like a bad load from cassette tape. This minor irritation is caused by BASIC's LIST processor's misinterpretation of the machine-language bytes. The effect is harmless.

Listing 2 is the program that uses POKE commands to place the KWIKLINE op codes into the dummy string. Line 10 reserves a block of memory for string storage and manipulation. BASIC must encounter this CLEAR command *before* the LN$ definition or its location will be unknown and the VARPTR function in line 30 will cause an error. Lines 30-50 determine the location of LN$ and set up the USR entry address. The same address is used in line 60 for the reference position to begin the POKEs. Then the DATA lines are read, converted from hexadecimal strings to decimal integers, and inserted into the dummy string. Line 110 calculates a checksum to avoid the possibility of a typo causing the program to bomb.

Once all the codes have been placed in the string, the unneeded lines are deleted from the program, leaving the base lines required for any access of KWIKLINE. Cassette-based system users should save this portion with CSAVE and use it as the starting kernel for experimentation. Disk-based system users must follow the instructions on line 50 and remember that the kernel program will not be correctly saved with the ASCII option. Instead, save any application programs with the command SAVE "DEMO1/BAS",A and merge that file with the result obtained from executing listing 2.

Lines 2000-2090 in listing 2 perform a simple test of the new graphics capability. Input some sample points at the prompts to verify that everything is working correctly.

KWIKLINE Operations

KWIKLINE, based on the DDA (digital differential analyzer) algorithm described by Mike Higgins (see "Fast Line-Drawing Technique," BYTE, August 1981, page 414), is very fast—the longest line requires 45 milliseconds to be drawn on an unmodified TRS-80 Model I. The routine uses only integer arithmetic and avoids redundant calculations.

Listing 1 is the assembly-language coding of KWIKLINE, showing the algorithm and the control loops that

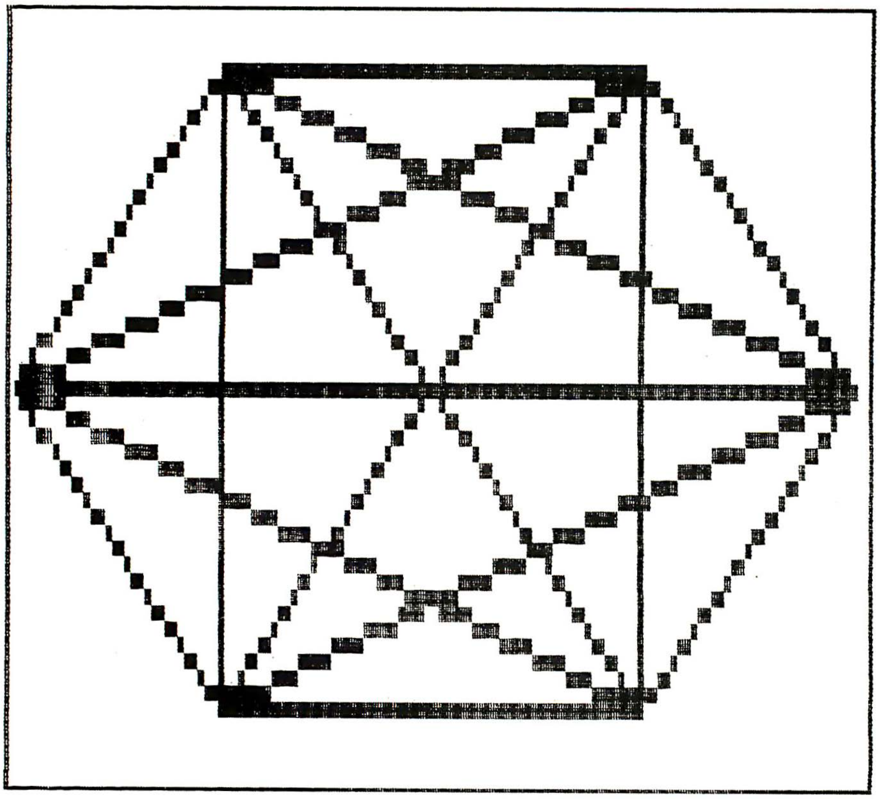


Figure 1: *Hexagon produced by the POLYGON program. The figure took approximately two seconds to draw by using the KWIKLINE program.*

implement it. Note that there are two nested loops. The inner loop plots the points along a line defined by the parameter string. The outer loop checks the extension character and loops back for further lines if necessary.

The first lines initialize the IX index register to point to the parameter string. The address supplied by the VARPTR function points to the variables-table byte that defines the length of the string. Since KWIKLINE does not use this byte, it is simply ignored. The following 2 bytes are the desired address in normal Z80 reverse order—LSB (least significant byte) followed by MSB (most significant byte).

Next, the line parameters are read and saved on the stack—their storage addresses will be temporarily used by the program. Increments and offsets for points along the line are calculated by lines 920-1130 and placed in the temporary storage area by lines 1160-1190.

The SET, RESET, and CHARACTER screen-address conversion routines are the heart of the program. Lines 1540-1680 find the screen address needed to place a byte in CHARACTER mode. Lines 1840-2170 convert an X,Y coordinate pair to the screen position and bit number that defines a certain pixel. The correct SET and RESET action is performed according to the fifth argument of the parameter string. This routine is exceptionally fast, interactive with BASIC, and relocatable.

Once a point has been plotted, the KWIKLINE routine adds offsets to registers D and E, which contain the current X and Y values, respectively. The B register, initialized to the length of the longest axis, is decremented and the rest of the line is plotted. When B goes to 0, lines 2520-2570 restore the original values to the parameter string. This is done to avoid having to redefine the string.

The EXTENSION character is then tested and, if it's not an ampersand character (&), control passes back to the BASIC interpreter; otherwise, the IX register is bumped to point to the next series of bytes, and a jump is made to the start of the outer loop.

One problem I encountered while writing KWIKLINE is that the distance between the start and end of the outer loop is greater than the 127 bytes maximum allowed a relative jump. Since KWIKLINE is written to be position-independent, the jump must be made via the "bridge" at line 1720. Another abnormality seen in the listing is the avoidance of bytes with a value of 00. After the code is placed into a BASIC program line, a zero byte would be interpreted as the End Of Line delimiter. The 2 bytes following the zero byte would be mistaken for a Next Line Pointer and the next 2 bytes as the line number, etc.

To avoid this mess, special steps must be taken. For example, it is necessary in line 2610 to load the DE register pair with the value 6 as an offset for the next set of line parameters. The op code

```
LD      DE,6
```

would ordinarily be assembled as 11 06 00, with the zero byte being unacceptable. Instead, the value is loaded in two steps:

```
LD      DE,0106H
DEC     D
```

The assembled code is 11 06 01 15, avoiding the zero byte. The end result is the same, but the code takes a little more time and memory. The tradeoffs of a slight loss in speed and size for relocatability and BASIC line compatibility are, nevertheless, a great bargain.

Drawing Lines from BASIC

KWIKLINE requires six 1-byte arguments—a starting coordinate (X1,Y1); an ending coordinate (X2,Y2); a SET, RESET, and CHARACTER mode byte; and an EXTENSION character—for each line drawn (see figure 1). Since BASIC allows the passing of only a single-integer argument to a USR routine, the arguments are concatenated into a string variable, and the storage address of this variable (VARPTR) is sent as a pointer to the arguments.

The starting and ending points may be anywhere on the screen and may define the same point. However,

Text continued on page 379

Listing 3: *The POLYGON program will draw a polygon with from 3 to 20 corners. POLYGON uses lines 10-50 of the KWIKLINE program to draw the lines.*

```
999 '
       This routine draws an N-gon with all vertices connected
       It expects lines 10-50 define the KWIKLINE subroutine

1000 DIM A(20),B(20) :PI=3.1416
1010 INPUT" # OF CORNERS (3-20)";N
1020 Z=0
1030 FOR J=0 TO 2*PI-.001 STEP 2*PI/N
1040    Z=Z+1
1050    A(Z)=COS(J)*63+63 :B(Z)=(SIN(J)*63+63)/127*47
1060 NEXT :CLS
1070 FOR J=1 TO N-1
1075   FOR K=J+1 TO N
1080       X1=A(J) :Y1=B(J) :X2=A(K) :Y2=B(K)
1090       GOSUB 2000
1100   NEXT K
1110 NEXT J
1120 K$=INKEY$ :IF K$="" GOTO 1120 ELSE 1010
1999 '
      Subroutine compiles the parameter string and draws
      a line of lit pixels as defined by the X1,Y1, X2,Y2
      endpoints.

2000 A$=CHR$(X1)+CHR$(Y1)+CHR$(X2)+CHR$(Y2)+ CHR$(1) +"."
2010 UU=USR(VARPTR(A$))
2020 RETURN
```

Listing 4: *The CLOCK-80 subroutine produces an analog- and digital-clock display on the screen. Again, it uses lines 10-50 of the KWIKLINE program.*

```
65 'NOTE: line 10 must CLEAR 10000 for fastest initialization

70 '             CLOCK-80
      Mechanical clock demonstration
          requires Disk BASIC
             and KWIKLINE

80 DIM CIR(59), S$(59,1), M$(59,1), H$(11,1) :DEFINT D-Z
90 DEF FN CX(A,B) = SIN(A) * B + 63
100 DEF FN CY(A,B) = (COS(A) * B + 63)/127*47 + 1
110 DEF FN BL$(E,F,G,H,M$,X$)=CHR$(E)+CHR$(F)+CHR$(G)+CHR$(H)
          + CHR$(-(M$="SET")-(LEN(M$)=1)*ASC(M$) ) + X$
120 DEF FN BX$(E,F,G,H,M,X$)=
     CHR$(E)+CHR$(F)+CHR$(G)+CHR$(F)+CHR$(M)+"&"
    +CHR$(G)+CHR$(F)+CHR$(G)+CHR$(H)+CHR$(M)+"&"
    +CHR$(G)+CHR$(H)+CHR$(E)+CHR$(H)+CHR$(M)+"&"
    +CHR$(E)+CHR$(H)+CHR$(E)+CHR$(F)+CHR$(M)+X$
130 SA=&H4041 :MA=&H4042 :HA=&H4043
    '** SYSTEM time addresses **
    Model III use > SA=&H4217 :MA=&H4218 :HA=&H4219

140 CLS :PRINT@ 411,"CLOCK-80"; :PRINT@ 473,"BY DAN ROLLINS";
150 PRINT@ 534,; :INPUT "TIME NOW (HH,MM,SS) ";H,M,S
160 POKE HA,H :POKE MA,M :POKE SA,S
170 PRINT@ 601," INITIALIZING"
180 Z=29 :B= 3.14159
190 FOR A= 2*B-.0001 TO 0 STEP -2*B/60 'define 60 points
200    Z=Z+1 :IF Z > 59 THEN Z=0         '  around circle
210    CIR(Z)= A
220 NEXT
230 FOR J=0 TO 59
240 SET(FN CX(CIR(J),61), FN CY(CIR(J),61))
250 '   Define seconds hand

260    K=J-30 :IF K<0 LET K=K+60
270    X1=FN CX(CIR(K),10)
280    Y1=FN CY(CIR(K),10)
290    X2=FN CX(CIR(J),55)
300    Y2=FN CY(CIR(J),55)
310    S$(J,0)=FN BL$(X1,Y1,X2,Y2,"RESET",".")
320    S$(J,1)=FN BL$(X1,Y1,X2,Y2,"SET",".")
330    'Define minutes hand

340    X2=FN CX(CIR(J),49)
350    Y2=FN CY(CIR(J),49)
360    M$(J,1)=FN BL$(X1,Y1,X2,Y2,"SET","&")
370    M$(J,0)=FN BL$(X1,Y1,X2,Y2,"RESET","&")
380    K=J-2 :IF K<0 LET K=K+60
390    X3=FN CX(CIR(K),35)
400    Y3=FN CY(CIR(K),35)
410    M$(J,1)=M$(J,1)+FN BL$(X2,Y2,X3,Y3,"SET","&")
420    M$(J,0)=M$(J,0)+FN BL$(X2,Y2,X3,Y3,"RESET","&")
430    K=J+2 :IF K>59 LET K=K-60
440    X3=FN CX(CIR(K),35)
450    Y3=FN CY(CIR(K),35)
460    M$(J,1)=M$(J,1)+FN BL$(X2,Y2,X3,Y3,"SET",".")
470    M$(J,0)=M$(J,0)+FN BL$(X2,Y2,X3,Y3,"RESET",".")
480 '  Define hours hand

490    IF INT(J/5) <> J/5 GOTO 640
500    L=J/5 :K=J-25 :IF K<0 LET K=K+60
510    X1=FN CX(CIR(J),35)
520    Y1=FN CY(CIR(J),35)
530    X2=FN CX(CIR(K),12)
540    Y2=FN CY(CIR(K),12)
550    H$(L,1)=FN BL$(X1,Y1,X2,Y2,"SET","&")
560    H$(L,0)=FN BL$(X1,Y1,X2,Y2,"RESET","&")
570    K=J+25 :IF K>59 LET K=K-60
580    X3=FN CX(CIR(K),12)
590    Y3=FN CY(CIR(K),12)
```

Listing 4 continued on page 378

Listing 4 continued:

```
600     H$(L,1)=H$(L,1)+FN BL$(X1,Y1,X3,Y3,"SET","&")
610     H$(L,1)=H$(L,1)+FN BL$(X2,Y2,X3,Y3,"SET",".")
620     H$(L,0)=H$(L,0)+FN BL$(X1,Y1,X3,Y3,"RESET","&")
630     H$(L,0)=H$(L,0)+FN BL$(X2,Y2,X3,Y3,"RESET",".")
640 NEXT
650 FR$=FN BX$(108,1,127,6,1,"&") + FN BX$(0,1,19,6,1,".")
660 '
        draw clock face

1000 CLS :H1=11 :M1=59 :S1=59
1010 FOR J=0 TO 59
1020    SET(FN CX(CIR(J),61), FN CY(CIR(J),61))
1030 NEXT :SET(2,27) :SET(125,27)
1035 UU=USRO(VARPTR(FR$)) :PRINT@ 65,"CLOCK-80";
1040 RESTORE :FOR J=1 TO 12 :READ K :PRINT@ K,J; :NEXT
1050 DATA 109,312,572,760,941,990,911,708,512,259,78,30

1060 '
        This loop draws the hands as the clock runs

1070 H=PEEK(HA) :M=PEEK(MA) :S=PEEK(SA)
1080    IF H>11 LET H=H-12 :POKE HA,H
1090    IF H1<>H THEN UU=USRO(VARPTR(H$(H1,0))) :H1=H
        :UU=USRO(VARPTR(H$(H1,1)))
1100    IF M1<>M THEN UU=USRO(VARPTR(M$(M1,0))) :M1=M
        :UU=USRO(VARPTR(M$(M1,1))) OR USRO(VARPTR(H$(H1,1)))
1110    IF S1<>S THEN UU=USRO(VARPTR(S$(S1,0))) :S1=S
        :UU=USRO(VARPTR(S$(S1,1))) OR USRO(VARPTR(M$(M1,1)))
        OR USRO(VARPTR(H$(H1,1)))
        :PRINT @ 119,USING "##:##:##";H-(H=0)*12,M,S;
1120    IF INKEY$ <>"" THEN 1140
1130 GOTO 1070
1135 '
        Press any key to reset the clock

1140 CLS :PRINT @ 470,; :INPUT "SET TIME (HH,MM,SS) ";H,M,S
1150 POKE HA,H :POKE MA,M :POKE SA,S :GOTO 1000
```

Listing 5: *The CHARACTER MODE subroutine produces either a moving frame around a message or flashes of lightning. It also uses lines 10-50 of the KWIKLINE program.*

```
70 CLS :INPUT "ROUTINE 1 OR 2";R
80 ON R GOSUB 100,1000
90 GOTO 70
99 '
   Two demos of CHARACTER mode:

   Lines 100-200 flash concentric squares of random characters
   Lines 1000-2000 frame the screen with "moving" lights
         and flashes lines ala Tesla

100 Q=0 :C$= "#*. +-" + CHR$(143)+CHR$(134)+CHR$(137)
110 CLS :PRINT@ 469,"YOUR SCORE IS ";SCORE
120 PRINT@ 594,"HIT <ENTER> TO PLAY AGAIN";
130 M$=MID$(C$,RND(LEN(C$)),1)
140 X1$=CHR$(Q*2) :Y1$=CHR$(Q) :X2$=CHR$(63-Q*2) :Y2$=CHR$(15-Q)
150 A$=X1$+Y1$+X2$+Y1$+M$+"&"+X2$+Y1$+X2$+Y2$+M$+"&"
      +X2$+Y2$+X1$+Y2$+M$+"&"+X1$+Y2$+X1$+Y1$+M$+"."
160 UU=USRO(VARPTR(A$))
170 Q=Q+1
180 IF Q=2 PRINT@ 599,"<--->";
190 IF Q=4 PRINT@ 599,"ENTER"; :Q=0
200 K$=INKEY$ :IF K$=CHR$(13) THEN RETURN ELSE 130
999 '

         Second CHARACTER mode demo
            "TRAPPED LIGHTNING"

1000 X1=0 :Y1=0 :X2=0 :Y2=15
1010 M=131 :GOSUB 2000 :LR$(0)=A$+"&"
1020 M=140 :GOSUB 2000 :LR$(1)=A$+"&"
1030 M=176 :GOSUB 2000 :LR$(2)=A$+"&"
1040 X1=63 :X2=63
1050 M=176 :GOSUB 2000 :LR$(0)=LR$(0)+A$+"."
1060 M=140 :GOSUB 2000 :LR$(1)=LR$(1)+A$+"."
1070 M=131 :GOSUB 2000 :LR$(2)=LR$(2)+A$+"."
1080 X1=1 :Y1=0 :X2=62  :Y2=0
1090 M=129 :GOSUB 2000 :TB$(0)=A$+"&"
1100 M=130 :GOSUB 2000 :TB$(1)=A$+"&"
1110 Y1=15 :Y2=15
1120 M=144 :GOSUB 2000 :TB$(0)=TB$(0)+A$+"."
1130 M=160 :GOSUB 2000 :TB$(1)=TB$(1)+A$+"."
1140 '
      Loop frames the screen with flashing lights
      and random lines are drawn and erased.  Use
            <ENTER> key to exit

1150 Q=2
1160 Q=Q+1 :IF Q>2 THEN Q=0
1170 UU=USR(VARPTR(LR$(Q))) OR USR(VARPTR(TB$(Q AND 1)))
1180 X1=63: Y1=23D:X2=2+RND(125) :Y2=RND(46) :M=1
1190 GOSUB 2000 :A$=A$+"&"+LEFT$(A$,4)+CHR$(0)+"."
1200 UU=USRO(VARPTR(A$)) :PRINT@ 470,"PRESS <ENTER> TO EXIT";
1210 IF INKEY$<>CHR$(13) THEN 1160 ELSE RETURN
1999 '
     subroutine compiles a line parameter string

2000 A$=CHR$(X1)+CHR$(Y1)+CHR$(X2)+CHR$(Y2)+CHR$(M) :RETURN
```

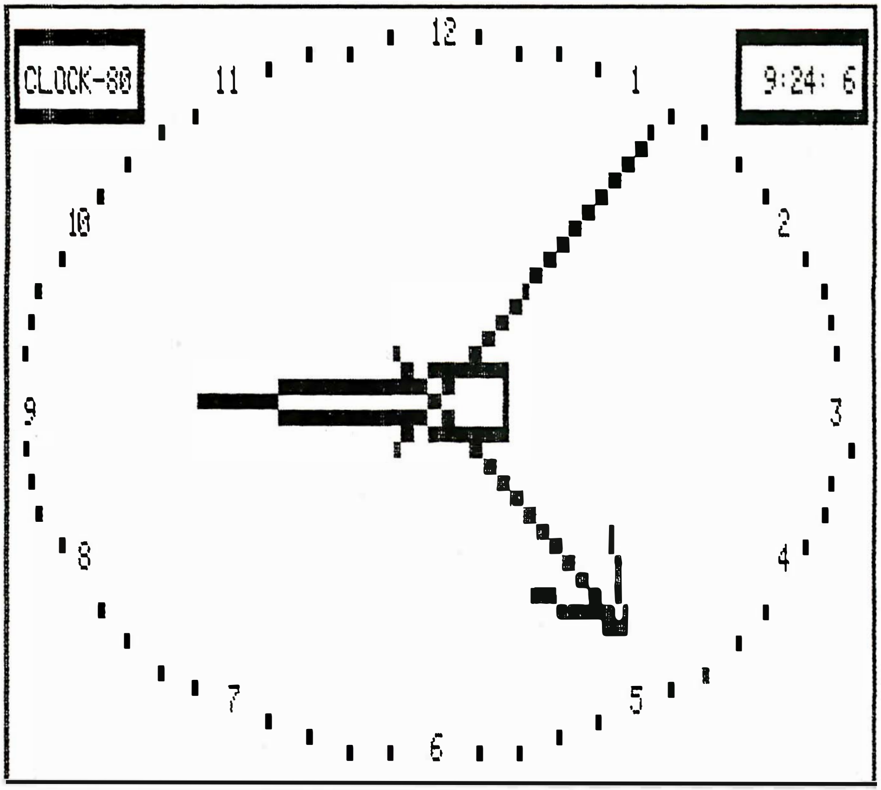


Figure 2: *Screen dump of the CLOCK-80 program. Each new position of the hands is determined by the KWIKLINE program.*

these values must agree with the mode byte. If incorrect parameters are passed, lines may be drawn at indeterminate screen locations (they generally "wrap around" the screen)—but the program will write only to video RAM (random-access read/write memory).

Two Modes

Two types of lines may be drawn using KWIKLINE. The SET/RESET mode uses the TRS-80 graphics pixel as the display medium. This mode requires the fifth byte of the argument string to be either a CHR$(0) for RESET, or CHR$(1) for SET. Arguments one through four, in this mode, must be in the order X1, Y1, X2, Y2, with the X values: 0 <= X =< 127 and the Y values: 0 <= Y =< 47. The fifth byte of the parameter string in the alternate mode, CHARACTER, will have a value >=2. The character in this position will be repeated along a line defined by the X,Y coordinate pairs, where 0 <= X <= 63 and 0 <= Y <= 15.

The sixth byte of the parameter string defines whether or not another set of line parameters follows the first. This byte must be an ampersand character (&), CHR$(38) for EXTENSION. Any other value forces a return to the calling BASIC program. When this byte is an ampersand, KWIKLINE expects six more parameter characters in the correct format in adjacent memory locations. The value of this function becomes apparent when a series of lines must be drawn consecutively. So much overhead is involved in compiling the parameter string and calling KWIKLINE from BASIC that optimum speed will not, otherwise, be obtained.

This function allows the programmer to define a parameter string of values for multiple lines, say four lines for a box, or two lines, one SET and the next RESET, for a phasor zap or bolt of lightning.

Listings 3, 4, and 5 demonstrate some techniques for compiling the strings for drawing the desired lines. Listing 3 draws a polygon with all vertices connected (see figure 1). The effect can appear very three-dimensional. This program uses the simplest form of parameter passing. The endpoints of the line are determined—note the scaling done to keep the figure symmetrical. Then, a GOSUB to line 2000 draws the line.

Listing 4 produces a simulation of

an analog clock—digital-clock simulations being passé (see figure 2). It uses a more advanced technique for maximum speed. An array of strings is compiled from the lines to be drawn. The lines define points between the center of the screen and points along the circumference of one of three concentric circles. The outermost circle is for the sweep-second hand, the middle one for the minute hand, and the inner circle defines the arc of the hour hand.

Once the array is compiled, disk BASIC's real-time clock is monitored and the screen is updated accordingly. The time is not determined from the TIME$ function, as manipulating this as a string would cause the delays associated with string reorganization. Instead, the clock's storage memory is examined using a PEEK command, and this numeric value is used as a pointer into the array of line parameter strings. So much string space is used by the program that almost *any* use of string-manipulation commands within this loop will eventually invoke the "garbage collector," in effect stopping time.

This clock program also demonstrates a drawback of KWIKLINE. Extensive string manipulation is required in defining each hand in every position on the face of the clock. Compiling all these strings takes about two minutes, a lengthy wait for a supposedly fast program! But the result, after the wait, is an example of the TRS-80 doing something that would seem beyond the capacity of a normal BASIC program. It is possible to eliminate this initialization phase by writing the string arrays to disk after the first compilation, and then reading the file upon subsequent runs.

Listing 5 produces demonstrations of the CHARACTER mode of KWIKLINE. These eye-catchers could be used in framing a company logo or luring an unsuspecting passerby into buying a product.

Portability, speed, and flexibility make KWIKLINE a valuable addition to the BASIC library. Learn to use this tool effectively, then stand back and watch as your graphics programs come alive! ■

Autograph: a Plotting Subroutine in TRS-80 Level II BASIC

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No one who remembers character graphics would deny that the ability to represent data graphically is an extremely attractive feature of many microcomputer systems. Yet some programmers still shy away from using graphics because writing programs for them can be tedious. And if you must include several formats or ranges of data values, graphics programs can get excessive.

My solution to such unwieldy programs is a subroutine I call Autograph. This program module automatically scales, titles, and plots data that is conducive to graphic treatment. When called, it displays a fixed chart border, automatically scales the y (vertical) graph axis to include any arbitrary data range, and positions and displays arbitrary titling strings. The latter includes the main title along the top of the display, the low title positioned along the bottom, and the vertical title positioned on the left side. In addition, the program labels the y-axis scale to match the data range.

The routine has no horizontal scale values as such. It does, however, allow any arbitrary number of x (horizontal) axis positions up to 104. Each position may correspond to a day, a week, a year, or any incremental value or event. The data for these positions can be automatically presented as points, ranges, or in bargraph (histogram) form.

For each horizontal position, Autograph plots y-axis data in three forms: point data, data ranges, and histograms (bar graphs).

I wrote Autograph in TRS-80 Microsoft BASIC. Before discussing the program in detail, however, a brief description of the TRS-80 Model I graphics system is in order. Such an explanation may help orient those who are interested in modifying the subroutine to use on other machines.

TRS-80 Graphics and Print-Character Positioning

Graphics for this popular microcomputer are implemented in the common rectangular format of cells. The cells on the video screen consist of rectangular elements that are oriented vertically and arranged in an array that is 128 cells wide and 48 cells high.

The programmer addresses the elements of this array in BASIC according to coordinates x and y. For example: cell (0,0) is located in the extreme upper left-hand corner; cell (0,2) appears two cells to the right. Following this pattern, cell (1,2) is immediately beneath (0,2). Cell (47,127) lies at the extreme lower right-hand position.

The BASIC statement SET(X,Y) turns on any particular graphics element. Similarly, RESET(X,Y) turns off any element.

This version of BASIC supports normal PRINT statements and makes alphanumeric character positioning easier by providing the statement PRINT@. The TRS-80 has a 1024-character display that is arranged in a format of 16 lines by 64 characters. The character (print) positions are numbered from 0 to 1023 for use in the PRINT@ statement. Position 0 is the first character in the top line of the display. Position 63 is the last character in this line. Position 1023 is the last character in the bottom line of the display.

Autograph uses the PRINT@ n statement and the string-handling operations LEN and MID$ to position

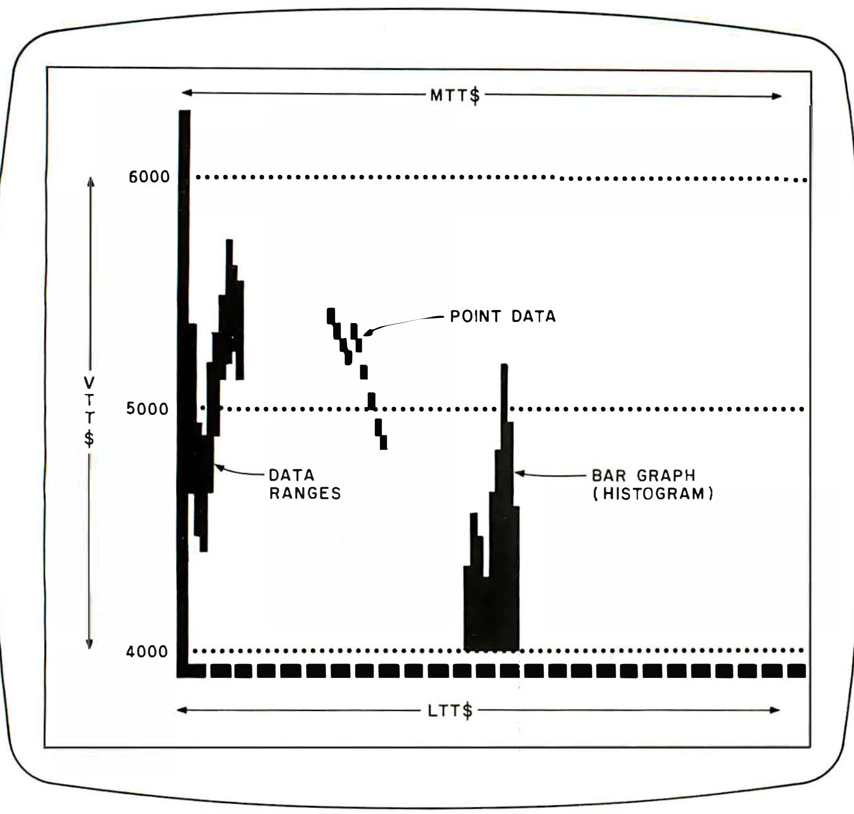


Figure 1: *An illustration of the screen layout of Autograph. Note the three automatic data-display modes.*

Listing 1: *The complete Autograph program, including a test section (lines 80–120). The program is in TRS-80 Level II BASIC. To use Autograph as a subroutine, delete the test section and the remarks at lines 50930–50950. Change line 50920 to RETURN.*

```
10 '-------- AUTOGRAPH --------
20 'By: Patrick E. McGuire
30 'Lafayette, LA --1980
40 'A program module for automatic graphing
50 'of data versus time.
60 'Test Section: This section allows input to test the
70 'autograph routine.
80 CLS: CLEAR 1000: DIM PLT(104,2)
90 INPUT"DATA POINTS";NDAT
100 FOR J=1 TO NDAT: PRINT J
110 INPUT PLT(J,1),PLT(J,2): NEXT J
120 INPUT"MTT$";MTT$: INPUT"LTT$";LTT$: INPUT"VTT$";VTT$
130 'End Test section
140 '------------------------------------------
50000 'Begin Subroutine "Autograph"
50010 'This section establishes the data maximum (HI)
50020 'and data minimum (LO).
50030 HI=PLT(1,1): LO=PLT(1,2)
50040 FOR I=1 TO NDAT
50050  IF PLT(I,1)>HI THEN  HI=PLT(I,1)
50060  IF PLT(I,2)<LO THEN  LO=PLT(I,2)
50070 NEXT I
50080 'End 'HI-LO' section
50090 '------------------------------------------
50100 'This section establishes the required number of
50110 'Y-axis divisions
50120 DIV=1: COM=11
50130  IF (HI-LO)<=COM GOTO 50150
```

Listing 1 continued on page 383

and print its titling strings. The *LEVEL II BASIC Reference Manual* and numerous other publications offer additional information about graphics on the TRS-80.

Autograph Layout

The chart borders in Autograph are fixed. The vertical border occupies a column of two adjacent cells with coordinates that begin at (22,3) and (23,3) and reach down to the two adjacent cells (22,41) and (23,41). The horizontal border is one cell high and extends from (22,42) through (127,42). The program reserves the space above and below the graph area for the main title and the low title, respectively. The space to the left of the graph area is for the *y*-scale labels and the vertical title. Figure 1 illustrates some features of the Autograph screen layout; 4000, 5000, and 6000 represent *y*-scale labels. Autograph divides the horizontal chart border into fixed increments of four plotting positions. This is easy to change, as I will explain later.

Figure 1 also illustrates Autograph's ability to plot data in three different modes. For each horizontal position, Autograph plots *y*-axis data in three forms: point data, data ranges, and histograms (bar graphs). The kind of plot it chooses depends on the data you give it. The method for giving data to Autograph is a sort of brute-force version of parameter-passing from the main program to the subroutine. I will explain later how to set up the main program to pass the data values to Autograph.

Using Autograph

To use Autograph, first enter listing 1 in its entirety and save it on disk or cassette tape. Listing 1 contains the Autograph subroutine, a test section (lines 80–120), and some remarks. To use the subroutine with a BASIC program, strip listing 1 of its test section and remarks (to save space) and then change the last line of listing 1 to RETURN. Save the resulting shorter version of Autograph on disk or cassette tape, too. When you start writing a new program that will use Autograph, you can first load this shorter version, the true subroutine.

Of course, your program will have to supply data for Autograph. We'll get to that in a moment.

The calling program must supply the following as assignment statements:

- NDAT: the number of horizontal increments for which data is to be plotted. The maximum is 104.
- MTT$: any string of up to 64 characters that will comprise the main title. This will be displayed along the top of the chart.
- LTT$: any string of up to 52 characters to make up the low title displayed below the chart.
- VTT$: a string of up to 13 characters that forms the vertical title. This will be displayed to the left of the chart's vertical border and scale labels.

These titling strings must be defined but may be empty (null).

Of course, you also have to supply the actual information to be plotted. The calling program does this by filling the array PLT(NDAT,2) with the information to be displayed. Data for the first horizontal position is inserted in PLT(1,1) and PLT(1,2). The process continues through the last data pair PLT(NDAT,1) and PLT(NDAT,2). Listing 2 shows how a program might supply data.

Supplying two data values for each plot position implements the automatic display of point data, ranges, or histograms. If a single point were to be plotted at position *X*, both PLT(X,1) and PLT(X,2) would be loaded with the same value. If a data range must be shown as a vertical stripe at the position, the program must load PLT(X,1) with the highest value of the range and PLT(X,2) with the lowest. To form a histogram with a base (bottom) value of V, PLT(X,1) would contain the data for position X and all PLT(X,2) array entries would be V.

In short, the entries in column 1 of PLT(NDAT,2) are the highest values to be plotted at a particular horizontal position, while the entries in the second column are the lowest.

Once all the data is set up, the program can call the subroutine.

Listing 1 continued:

```
50140  DIV=DIV*10: COM=COM*10:  GOTO 50130
50150 MAX=INT(HI/DIV)*DIV+DIV
50160 MIN=INT(LO/DIV)*DIV
50170 DELTA=MAX-MIN: FACT=.1
50180 FACT=FACT*10
50190  IF DELTA <= FACT THEN SC=1 ELSE GOTO 50210
50200  GOTO 50340
50210  IF DELTA <= (2*FACT) THEN SC=2 ELSE GOTO 50230
50220  GOTO 50340
50230  IF DELTA <= (3*FACT) THEN SC=3 ELSE GOTO 50250
50240  GOTO 50340
50250  IF DELTA <= (4*FACT) THEN SC=4 ELSE GOTO 50270
50260  GOTO 50340
50270  IF DELTA <= (6*FACT) THEN SC=6 ELSE GOTO 50290
50280  GOTO 50340
50290  IF DELTA <= (12*FACT) THEN SC=12 ELSE GOTO 50180
50300 'End Y-axis division section.
50310 '----------------------------------------
50320 'This section establishes the maximum and minimum
50330 'chart values.
50340 IF SC<6 THEN GOTO 50380
50350 BTM=MIN:
50360 HSC=MAX+INT(SC-INT((MAX-BTM)/FACT))*FACT
50370 GOTO 50390
50380 HSC=MAX
50390 SKIP=768/SC: LNS=SC
50400 IF SC=1 LNS=4
50410 'End chart max-min section
50420 '----------------------------------------
50430 'This section displays the chart borders.
50440 CLS
50450  FOR Y=3 TO 41:SET(22,Y): SET(23,Y): NEXT Y
50460  FOR X=22 TO 127: SET(X,42): NEXT X
50470  FOR X=27 TO 127 STEP 4: RESET(X,42): NEXT X
50480 'End chart border section
50490 '----------------------------------------
50500 'This section labels the Y-axis scale.
50510 VSC=HSC+FACT
50520  FOR Y=69 TO 837 STEP SKIP
50530  VSC=VSC-FACT
50540  PRINT@Y,VSC;
50550  NEXT Y
50560 'End Y-axis labelling.
50570 '----------------------------------------
50580 'This section divides the chart vertically with
50590 'periods (.).
50600 PS=76:CK=-1
50610 PRINT@PS,;
50620  FOR PT=1 TO 52: PRINT".";: NEXT PT
50630 PS=PS+(12/LNS)*64: CK=CK+1
50640 IF CK=LNS GOTO 50690
50650 GOTO 50610
50660 'End vertical division section.
50670 '----------------------------------------
50680 'This section prints titles.
50690 TL=LEN(MTT$): LFT=INT((64-TL)/2)
50700 PRINT@LFT,MTT$;
50710 HGT=LEN(VTT$)
50720 IF HGT>13 THEN HGT=13
50730 PC=128+64*INT((12-HGT)/2)
50740 FOR S=1 TO HGT
50750 P$=MID$(VTT$,S,1)
50760 PRINT@PC,P$;
50770 PC=PC+64
50780 NEXT S
50790 TL=LEN(LTT$): LFT=971+INT((52-TL)/2)
50800 PRINT@LFT,LTT$;
50810 'End title printing.
50820 '----------------------------------------
```

Listing 1 continued on page 384

Listing 1 continued:

```
50830 'This section actually graphs the data.
50840 X=23
50850  FOR I=1 TO NDAT
50860  X=X+1
50870  DH=INT(((HSC-PLT(I,1))/(HSC-MIN))*36)+5
50880  DL=INT(((HSC-PLT(I,2))/(HSC-MIN))*36)+4
50890  FOR Y=DH TO DL: SET(X,Y)
50900  NEXT Y
50910  NEXT I
50920 GOTO 50920
50930 'End of module. Change line 50920 to 'RETURN' and
50940 'delete test section lines after debugging
50950 'keyboard program entry.
```

Listing 2: *A routine that illustrates how to make a program pass data to the Autograph subroutine. NDAT is the number of horizontal points to plot, PTS is a variable representing points to plot, and MTT$, LTT$, and VTT$ are strings to be printed on the graph as titles.*

```
130 NDAT=35
140 FOR PTS=1 TO NDAT
150 PLT(PTS,1)=WTEMP(PTS,2)
160 PLT(PTS,2)=WTEMP(PTS,1)
170 NEXT PTS
180 MTT$="TURTLE RUN, PA - TEMP."
190 LTT$="WEEKLY DATA"
200 VTT$="DEGREES, F."
```

An Example

The manipulation required prior to entering into the subroutine is best described by an example.

Assume that data representing the weekly temperature range for a small town in Pennsylvania is stored in a main program array called WTEMP(35,2). This would represent 35 weeks of data. Assume that the first row of the array contains the lowest temperature and the second row contains the highest, exactly the opposite order required by Autograph. One possible program sequence to set up the data for use in the subroutine appears in listing 2. This routine results in the display of data ranges.

To plot only the weekly high temperatures, you could replace line 160 in listing 2 with

```
160 PLT(PTS,2) = PLT(PTS,1)
```

If, on the other hand, you wanted a zero-based histogram of weekly low temperature, you could change lines 150 and 160 to

```
150 PLT(PTS,1) = WTEMP(PTS,1)
160 PLT(PTS,2) = 0
```

Note that the limits for the order of magnitude of data are about 0.1 to 8999. Data outside these limits can be conditioned to fall within the bounds when you set up the subroutine. For example, you could show five-figure dollar amounts as thousands of dollars. The titling strings, of course, should reflect such a change. These limits are imposed not by the program algorithms but by the space allocated for labeling the *y* axis.

How Autograph Works

Listing 1 shows the Autograph program itself. The first section, lines 80–120, forms a short testing routine. Here you are asked to supply the number of data points (NDAT). This continues with data entry of the high and low values, in order, for each point. Finally the test routine asks for the titling strings. As I mentioned before, these lines would be deleted to use Autograph as a subroutine. This section simply tests the data to determine the highest and lowest values. Lines 50030–50070 begin the actual Autograph subroutine.

The program section from lines 50120 to 50290 determines the number of major *y*-axis divisions needed to display the data. Given the layout of Autograph, the maximum number of divisions is 12 (1 is the minimum). You can use intermediate divisions of 2, 3, 4, and 6 to spread the data over most of the screen area set aside.

The first part of this section normalizes the difference between the data high and low to a range less than 11. DIV is the variable that does this. The value of DIV is set by the number of loops through the sequence 50130–50140. Each loop through the sequence multiplies DIV and the variable COM by 10. If HI-LO is less than the generated value of COM, then DIV is the correct divisor to form MAX and MIN. For example, if your data range were 80–105, MAX and MIN would end up 110 and 80. Thus the minimum scale range required to display the data would be MIN to MAX. The section consisting of lines 50170–50290 establishes the actual number of divisions that will be used on the *y* axis. This is also a normalization sequence that acts on the value of MAX-MIN. It determines which of the six allowed division increments is the smallest that will fit the data range. This number is passed on to the rest of the program as the variable SC.

Lines 50340–50400 use data generated in the previous program section to determine the value of HSC. This is the label for the maximum *y*-axis division. HSC and SKIP will later establish all the major division labels. The *y* axis is also subsequently divided by horizontal rows of periods. The number of rows is set equal to the number of labeled divi-

sions except when SC is 1. In that case, the scale will be divided into quarters by additional lines of periods. LNS is the variable that controls period row-generation.

The sequence of lines 50430–50470 is a simple graphics routine that sets the chart borders. Note that line 50470 is a FOR...NEXT loop to divide the horizontal axis into increments of four plotting positions. You can change this by altering the step size of the loop. For example, if you were displaying daily data, a more appropriate step size might be 7, which would correspond to one week of data. If you wanted to, you could make the step size a variable that is set by the calling program.

The next section of listing 1, lines 50471–50550, labels the *y*-axis scale. The variable *y* is initialized at 69 to define the print position immediately to the left of the top scale line. This value is sequenced through print position 837, which is adjacent to the bottom of the *y* axis. The variable SKIP was generated earlier and is directly related to the number of major divisions fixed for the data being plotted.

The next sequence of lines, through 50650, prints periods at the major divisions to make the chart easier to read.

Next, a string-manipulating routine beginning with line number 50680 centers the titling strings and displays them.

The final section, beginning with line number 50840, plots the data. The algebraic manipulations in this section proportion the data within the total range of plot positions, which results in cell addresses for the highest and lowest range to be plotted at particular horizontal positions. A FOR... NEXT loop then turns on the appropriate graphics cell or cells.

Final Remarks

Using Autograph will let you incorporate graphics displays into programs comparatively painlessly. The only thing you sacrifice for not using a custom routine in every case is speed. The information on Autograph's operation should help you to develop a customized version if speed is a problem in your applications. ■

Book Reviews

Silent Witness: A Novel of Computer Crime

Ed Yourdon
Yourdon Press
New York, 1982
177 pages,
hardcover, $12.95

Reviewed by
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c/o BYTE Publications
POB 372
Hancock, NH 03449

As its jacket copy testifies, *Silent Witness* is a story of "computer crime, a missing person, love, dashed dreams, and a chance to start over." If you think that sounds like a cross between "Hill Street Blues" and *Love's Tender Fury*, high-technology style, you're not far wrong.

The premise of Ed Yourdon's first novel is predictable enough. Tony and Max, a computer operator and a programmer, devise a get-rich-quick scheme that involves embezzling $3 million from Max's employer, a bank by the unlikely name of Metripolidollar. To put the plan in motion, Max creates 30 bogus corporations, authorizes them to borrow up to $100,000 without collateral, opens 600 personal accounts at different branches (are you getting all this down?), and then proceeds to withdraw the maximum from each account. Presto: $3 million. That's where the second half of the plan comes in: they'll parlay the cash into multiple millions and cover their tracks before anyone's the wiser. What happens when the plan goes awry, as of course if does, is the subject of *Silent Witness.*

Enter a cast of characters of the stock variety. In addition to streetwise Tony and paranoid Max, we have Andrea, the (what else) beautiful rookie cop; Bernie Kaplan, super schlemiel; Hogie, rough-hewn programming genius; Cooper Harrison, detective extraordinaire; and a few extras with names that would have made Damon Runyon proud. The entire cast, naturally, has a personal or professional stake in the final resting place of the aforementioned $3 million.

The telling of the tale is more engaging. *Silent Witness* is a series of entries, stamped with the date and time, that are told from the perspective of different characters. Consequently, we have a bird's eye view of the agonies and the ecstasies (I'll get to computer love in a moment) of criminal, investigator, and innocent bystander alike. In between these scenes, an omniscient narrator keeps us up to date on the other characters' movements in and around Manhattan, the scene of the crime.

Because each segment focuses on only a few hours—the action takes place in 23 days—the story moves swiftly, gathering momentum along the way. Yourdon has managed to sustain the element of suspense throughout; at times I distinctly heard a clock ticking dramatically in the background.

Yourdon has clearly drawn on his background as a data processing consultant, and his technical expertise lends the dialogue and plot its ring of truth. Unfortunately, the author just can't keep the consultant down, which results in passages straight out of Computer Science 101: "Application programmers write English-like statements such as y = x + 1, which are translated by the compilers into assembly language. . . ." Such explanations are instructive, perhaps, but they are tedious here.

Yourdon also uses *Silent Witness* to vent his views on the hierarchy of the computer science establishment. Ostensibly for the benefit of the uninitiated, his chapters are laced with lines such as these:

Computer professionals can tell a lot about each other by looking at the way they dress and at the formats of the programs they read. One who wears a suit, and who gets his hair cut regularly, is probably an application programmer or maybe a systems analyst. A data-processing expert in baggy pants and a wrinkled shirt, or sporting a beard and sandals, is likely to be a systems programmer, or possibly a computer operator . . . in the computer field, though, operators are regarded as mechanics . . . they rank at the bottom of the pecking order.

One passage that I found instructive *and* entertaining illustrates how a team of investigators might use databases to track down a criminal. The question in this case is, "Can a new millionaire's seemingly petty purchases betray him?" Databases may be old hat to a seasoned professional, but Yourdon's description of them is the sort of graphic example a novice can appreciate.

If believability is one criterion of good fiction, *Silent Witness* succeeds only half the time. While most of the details of the crime and the ensuing investigation are plausible, the ending is pure "Fantasy Island." The requisite love scene that Yourdon included is just as embarrassing. A case in point: "She felt herself burst into flames feeling his tongue flicker against hers." Lines like that give fiction a bad name.

In spite of its obvious lapses, *Silent Witness* is a fairly engaging behind-the-scenes look at the world according to computer professionals. Because it illustrates the extent to which computers pervade our culture and explains certain fundamental principles as well, the book may be particularly appealing to anyone just discovering the world of computers. This may be the perfect opportunity to introduce your technophobic friends to the mysteries of the science. ■

BYTE's Bits

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Sapana Micro Software is developing a database of hardware and software for the IBM Personal Computer. The listing will be divided into separate hardware and software sections, indexed by title and source, and include the product's name, configuration required, available form, distribution details, and other pertinent data. Two monthly listings will be produced, one covering new additions to the market and the other listing products available to date.

Interested parties developing hardware and software for the IBM Personal Computer and individuals seeking such items are invited to contact Sapana Micro Software, POB 748, Quincy, IL 62301. ■

Another Binary to BCD Conversion Routine

Pat Coghlan and George White
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Ottawa, Ontario K1N 9B4 Canada

While trying to transport the multibyte binary to binary-coded-decimal (BCD) routine described by Michael McQuade in the February 1980 BYTE (page 106) to a 6502-based computer, we discovered that the flowchart on page 112 would not work. As given, this flowchart yields the proper results only if the value of the binary field is 0. Inspecting the last small loop of the flowchart will reveal the reason for this quirk.

Suppose the BCD field is large compared to the binary field. The carry bit will be a 0 upon entry to the loop. The least significant byte of the BCD field is then added to itself along with the carry (which is 0), and eventually the RETURN box is entered. Since the least significant byte is *always* added to itself, the resulting number will always be even.

Having one too many loops in a routine is a common problem that, once identified, is easily fixed. In this case, two changes are necessary. The bit counter should be initialized to 8 × D − 1 rather than 8 × D, and the final carry should be added to the BCD field without also adding the byte to itself. Figure 1 shows the repaired flowchart. Our version uses two subroutines to enhance the modularity and improve the understanding of the algorithm. Although we made this change at the expense of some run-time efficiency, we feel the trade-off is definitely worthwhile.

Listing 1 is the conversion routine implemented in 6502 assembly language. It has been tested on an Apple II but should work on any 6502-based machine, such as a KIM-1 or a PET.

Finally, *rotation* of the entire binary field is not strictly necessary. A left shift of this field would do just as well. Implementing such an operation may best be done with several 9-bit rotations involving the carry bit.■

Listing 1 is on pages 388-390

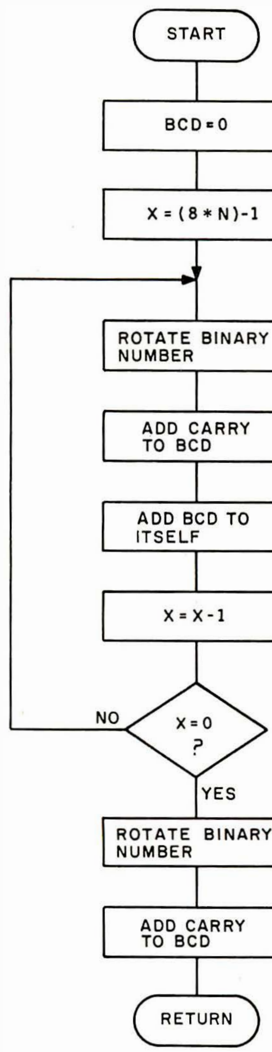


Figure 1: *Flowchart of the binary to binary-coded-decimal (BCD) routine given in listing 1.*

Listing 1: *The 6502 assembly-language implementation of the binary to binary-coded-decimal routine. Written on an Apple II, it can easily be modified to run on any 6502-based machine.*

```
                        1000 ***************************************************
                        1010 *                                                 *
                        1020 * THIS SUBROUTINE WILL TAKE AN UNSIGNED INTEGER   *
                        1030 * OF LENGTH N BYTES (SPECIFIED BY CALLER) AND     *
                        1040 * PRODUCE THE BINARY CODED DECIMAL REPRESENTATION *
                        1050 * IN A FIELD OF LENGTH M BYTES (ALSO SPECIFIED BY *
                        1060 * CALLER).                                        *
                        1070 *                                                 *
                        1080 * PROGRAM AUTHOR: PAT COGHLAN                     *
                        1090 * DATE WRITTEN:    80/04/05                       *
                        1100 *                                                 *
                        1120 * THE FOLLOWING PARAMETERS MUST BE PASSED TO THIS *
                        1130 * SUBROUTINE FROM THE CALLING PROGRAM:            *
                        1140 *                                                 *
                        1150 * ADDRESS (LENGTH)     DESCRIPTION                *
                        1160 *                                                 *
                        1170 *  $50   (2)           ADDRESS OF INPUT BINARY #  *
                        1180 *  $52   (1)           NUMBER OF BYTES IN BIN. #,N *
                        1190 *  $53   (2)           ADDRESS OF OUTPUT BCD #    *
                        1200 *  $55   (1)           NUMBER OF BYTES IN BCD #,M *
                        1210 *                                                 *
                        1220 * IT IS ASSUMED THAT THE OUTPUT FIELD IS LARGE    *
                        1230 * ENOUGH TO ACCOMMODATE THE RESULT                *
                        1240 *                                                 *
                        1250 ***************************************************
                        1260 *
                        1270 BCNT .EQ $52          ADDRESS OF BIN FIELD LENGTH
                        1280 DCNT .EQ $55          ADDRESS OF BCD FIELD LENGTH
                        1290 BIN  .EQ $50          ADDRESS OF BIN BIELD
                        1300 BCD  .EQ $53          ADDRESS OF BCD FIELD
                        1310 *
0800- A9 06             1320 CALL LDA #6
0802- 85 52             1330      STA BCNT
0804- 85 55             1340      STA DCNT         #BCD BYTES
0806- A9 1C             1350      LDA #BFLD        ADDRESS OF BIN
0808- 85 50             1360      STA BIN
080A- A9 08             1370      LDA /BFLD
080C- 85 51             1380      STA BIN+1
080E- A9 22             1390      LDA #DFLD        ADDRESS OF BCD
0810- 85 53             1400      STA BCD
0812- A9 08             1410      LDA /BFLD
0814- 85 54             1420      STA BCD+1
0816- 20 28 08          1430      JSR BNCD
0819- 4C 03 10          1440      JMP $1003
081C- 00 00 00
081F- 00 00 FF          1450 BFLD .HS 0000000000FF
0822- FF FF FF
0825- FF FF FF          1460 DFLD .HS FFFFFFFFFFFF
                        1470 *
                        1480 *
0828- 48                1490 BNCD PHA              SAVE AC
0829- 8A                1500      TXA
082A- 48                1510      PHA              SAVE X REG
082B- 98                1520      TYA
082C- 48                1530      PHA              SAVE Y REG
082D- F8                1540      SED              SET DECIMAL MODE
```

```
082E- A4 55           LDY DCNT       #BCD BYTES
0830- F0 2E           BEQ RTRN       RETURN IF LENGTH 0
0832- A9 00           LDA #0         NOW ZERO OUT BCD FIELD
0834- 88         ZERO DEY            ADJUST DISPLACEMENT
0835- 91 53      ZELP STA (BCD),Y    ZERO LOOP
0837- 88              DEY
0838- 10 FB           BPL ZELP       LOOP UNTIL Y=-1
083A- A5 52      SETC LDA BCNT       #BIN BYTES
083C- F0 22           BEQ RTRN       RETURN IF 0
083E- 0A              ASL            BIT COUNTER = 8*#BIN BYTES
083F- 0A              ASL
0840- 0A              ASL
0841- AA              TAX            USE X AS SHIFT COUNTER
0842- CA              DEX
0843- 20 66 08   ROTA JSR FLIP       SHIFT ENTIRE BIN FIELD LEFT
0846- 20 77 08   PROP JSR PBCD       ADD CARRY TO BCD FIELD
0849- A4 55           LDY DCNT       #BCD BYTES
084B- 88              DEY            ADJUST DISPLACEMENT
084C- B1 53      SELF LDA (BCD),Y    ADD BCD FIELD TO ITSELF
084E- 85 56           STA $56
0850- 65 56           ADC $56
0852- 91 53           STA (BCD),Y    REPLACE BYTE
0854- 88              DEY
0855- 10 F5           BPL SELF       DO ALL BYTES
0857- CA              DEX            CHECK SHIFT COUNTER
0858- D0 E9           BNE ROTA
085A- 20 66 08   DONE JSR FLIP       RESTORE BIN # TO ORIGINAL INPUT
085D- 20 77 08        JSR PBCD       ADD FINAL CARRY TO BCD FIELD
0860- 68         RTRN PLA            GET X REG
0861- AA              TAX
0862- 68              PLA            GET Y REG
0863- A8              TAY
0864- 68              PLA            GET AC
0865- 60              RTS            RETURN
                 *
                 * SUBROUTINE TO SHIFT ENTIRE  BIN # LEFT 1 BIT
                 *
0866- A0 00      FLIP LDY #0         POINT TO HIGH BYTE
0868- B1 50           LDA (BIN),Y    GET HIGH BYTE OF BINARY NUMBER
086A- 2A              ROL            SET CARRY FROM HIGH BYTE SHIFT
086B- A4 52           LDY BCNT       #BINARY BYTES
086D- 88              DEY            ADJUST DISPLACEMENT
086E- B1 50      SHIF LDA (BIN),Y    GET NEXT BINARY BYTE
0870- 2A              ROL            ROTATE LEFT
0871- 91 50           STA (BIN),Y    REPLACE BYTE
0873- 88              DEY            MOVE TO NEXT BYTE ON LEFT
0874- 10 F8           BPL SHIF
0876- 60              RTS
                 *
                 * THIS SUBROUTINE WILL ADD THE INCOMING CARRY TO
                 * THE ENTIRE BCD NUMBER FIELD
                 *
0877- A4 55      PBCD LDY DCNT       #BCD BYTES
0879- 88              DEY            ADJUST DISPLACEMENT
087A- B1 53      ADD  LDA (BCD),Y    GET NEXT BCD BYTE (R TO L)
087C- 69 00           ADC #0         ADD CARRY FROM PREVIOUS ADD
087E- 91 53           STA (BCD),Y    REPLACE BYTE
```

Listing 1 continued on page 390

Listing 1 continued:

```
0880-  90 02        2120          BCC RETI         RETURN IF NO MORE CARRYS
0882-  10 F6        2130          BPL ADD
0884-  60           2140 RETI     RTS


SYMBOL TABLE

BCNT   0032      DCNT   0033      BIN    0050
BCD    0055      CALL   0800      BFLD   081C
DFLD   0822      BNCD   0828      ZERO   0834
ZELF   0835      SETC   083A      ROTA   0843
PROP   0846      SELF   084C      DONE   085A
RTRN   0860      FLIP   0866      SHIF   086E
PBCD   0877      ADD    087A      RETI   0884
```

BYTE's Bugs

Heuristic Tree Search Not Admissible

A design error in the main program associated with Gregg Williams's article "Tree Searching" ("Part 1, Basic Techniques," September 1981 BYTE, page 72 and "Part 2, Heuristic Techniques," October 1981 BYTE, page 195) resulted in a program that works but is theoretically incorrect. For a heuristic search to be *admissible* (i.e., finding an optimal solution), nodes of the search tree must be evaluated by the function:

$$\hat{f}(n) = \hat{g}(n) + \hat{h}(n)$$

An oversight on the part of the author resulted in the BASIC program in part 1, listing 1a (page 80), evaluating the above equation without the $\hat{g}(n)$ term. (The $\hat{g}(n)$ represents the estimate of the shortest path from the start node to the current node n. Since we are dealing with trees, which have only one such path to any node, the $\hat{g}(n)$ value is also a $g(n)$ value, where $g(n)$ is, theoretically, the shortest path from the start node to node n.)

Although the program still solves the puzzles given to it, the lack of admissibility does not *guarantee* a solution under all circumstances, nor does it guarantee the *shortest possible* solution. The changes shown in the listing below, when added to listing 1a, correct the program to include the $g(n)$ term. The format of a node stored in the string array O$ is altered to be as follows:

O$(3)="001U12345.786001"

- $\hat{g}$ value of node, O8 digits long
- row-major layout of board, R9*R9 digits long
- move code to get from parent to current node
- parent node number, O8 digits long

In an unrelated item, it should be pointed out that the program can be expanded to deal with larger problems simply by expanding the dimensions of the O, O$, and R$ arrays in line 100 of listing 1a.

Finally, the author would like to thank Dr. Henry W. Davis, Associate Professor of Computer Science at Wright State University (Dayton, Ohio), for pointing out this error. ■

Listing 1

```
]LIST 244-245

244  REM  --G9 IS G-HAT VALUE FROM STRING O$
245 G9 =  VAL ( MID$ (O$(N1),H2,O8))


]

]LIST 402-405

402  REM  --G-HAT VALUE OF SUCCESSOR--G9+1--IS ADDED TO H-HAT VALUE
403  REM     IN R1 TO GIVE TRUE F-HAT VALUE
405 R1 = (G9 + 1) + R1


]

]LIST 9301-9303

9301  REM  --PUT G-HAT AT END OF STRING
9302 N9 = N1: GOSUB 9400:Z9$ = Q$:N1 = G9 + 1: GOSUB 9400:N1 = N9
9303 A$(A9) = Z9$ +  MID$ (D$,S1,1) + F$ + Q$


]

]LIST 9523

9523  REM   --PUT 'Q2$="<STARTING PATTERN>":GOTO 9535' HERE TO BYPASS INPU
     T OF PUZZLE EACH TIME PROGRAM IS RUN
```

Listing 1 continued on page 392

Listing 1 continued:

```
]LIST 9551-9553

9551  REM  --ADD G-HAT VALUE TO END OF STRING
9552 N1 = 1: GOSUB 9400:Z9$ = Q$
9553 N1 = 0: GOSUB 9400:O$(1) = Z9$ + "B" + Q2$ + Q$:N1 = 1


]LIST 9576-9577

9576  REM  --H2=FIRST CHAR. OF G-HAT VALUE WITHIN STRING O$
9577 H2 = O8 + L2 + 2


]

]LIST 9614-9615

9614  REM  --Q4$ IS BOARD IN STRING FORM ; COMPARE TO GOAL STRING, Q3$
9615 Q4$ =  MID$ (A$(M1),H1 + 1,L2)
```

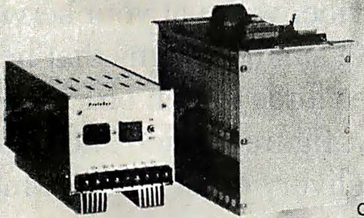
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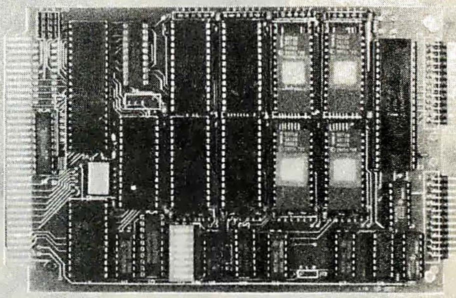
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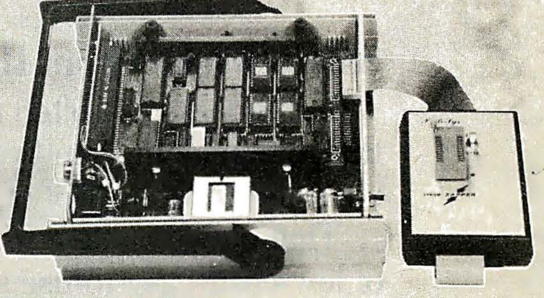
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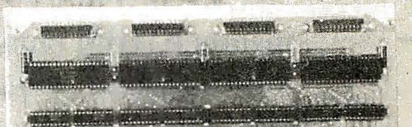
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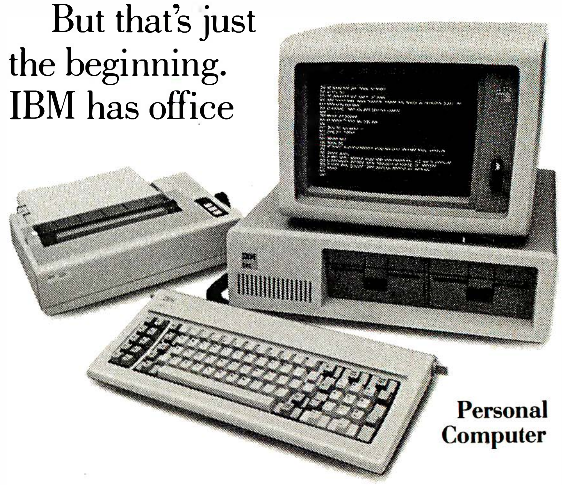
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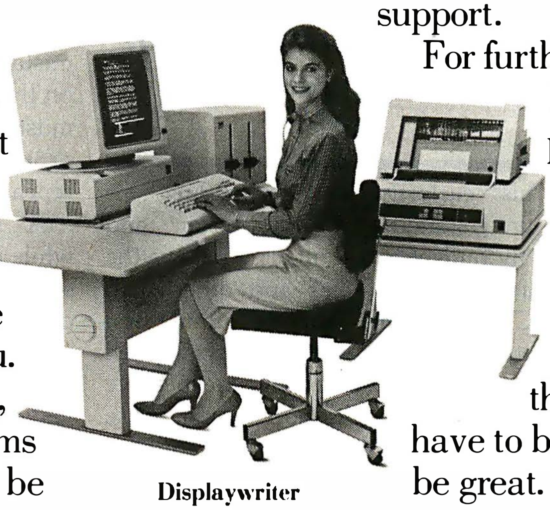

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Simulation of Simple Digital Logic through a Computer-Aided Design System

Home-computer logic designers now can have a computer-aided design system comparable to professional systems in all aspects but speed.

Robert McDermott
33 Dora Circle
Bridgeport, CT 06604

Computer-aided design is not something one normally considers for home use—professional CAD (computer-aided design) systems cost half a million dollars and require memory capacity measured in megabytes. But after my son outgrew his "150-in-1 Electronics Experiments" kit, CAD seemed like the next logical step for a tinkerer on a budget.

With the power of home computers approaching that of the large computers of past decades, CAD for hobby applications has become feasible. One of the basic CAD programs suitable for such implementation is a *logic simulator*, a software-based breadboard that allows simulation of a digital circuit with no investment in parts.

A large portion of the code and storage requirements of a professional logic simulator deals with sophisticated processing to reduce run times and with the ability to handle chips containing 100,000 or more logic gates. With the availability of "free" computer time at home, and the expectation that hobby designs would be small (fewer than 100 gates), I felt that a logic simulator could be squeezed into a typical 16K-byte computer.

After completing the project, I was amazed to find that such a system could be programmed with fewer than 200 BASIC statements! My son can now experiment freely, satisfying his curiosity and expanding his understanding of logic design, and my budget is still intact. I believe the availability of this and other such CAD systems (circuit simulators, etc.) will assist experimenters as well as provide excellent and inexpensive teaching tools. As more designers use CAD, the availability of CAD at high school and college levels will increase, and students will receive important exposure and experience in computer-aided design. The following discussion, flowchart, examples, and program listing are provided to foster expanded CAD use.

Using a software-based "breadboard," you code a proposed design into the computer as an interconnection of various types of logic gates.

Using a Logic Simulator

You use a logic simulator in the same way that you use a hardware-based breadboard: you interconnect various logic gates to perform the proposed functions, apply power, and test the circuit by applying some *input stimuli* and observing the resultant output.

If the output is as expected, you can implement the design in a final form (printed-circuit board, etc.). All too frequently, however, the output is not as expected, due to a basic flaw in the logic implementation, a mistake in the wiring, or a faulty gate on the breadboard. At this point, you must go through the time-consuming process of locating the problem and repeat the procedure.

A software-based "breadboard," while used in the same way, has some significant advantages. You code the proposed design into the computer as an interconnection of the various logic gates (the number and types of gates available for use is limited only by the program's capabilities, not by the contents of your spare-parts collection). After all the devices are "interconnected" in software, you can instruct the simulator to supply a series of input stimuli to test and

About the Author

Robert M. McDermott is the manager of CAD Software Engineering at International Telephone and Telegraph's LSI Technology Center. He teaches computer science at Bridgeport Engineering Institute and has a B.E.E., an M.S. in computer science, and an M.S. in systems analysis.

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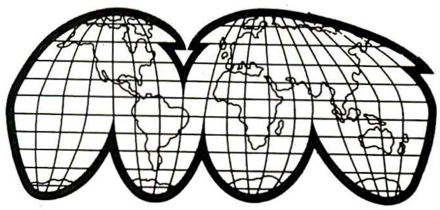
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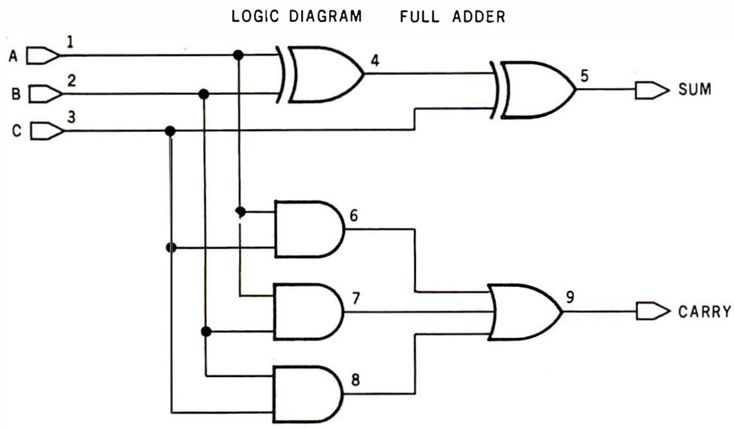
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LOGIC DESCRIPTION TO SIMULATOR

```
X,  1,  2,   ,   ,   ,  4,
X,  3,  4,   ,   ,   ,  5,
A,  1,  3,   ,   ,   ,  6,
A,  1,  2,   ,   ,   ,  7,
A,  2,  3,   ,   ,   ,  8,
O,  6,  7,  8,   ,   ,  9,
END,,,,,,,
```

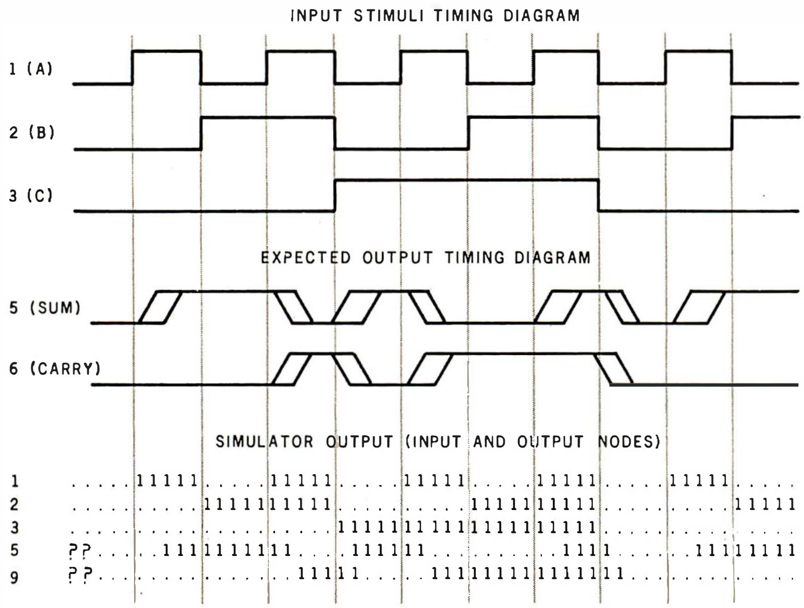


Figure 1: *Example application of the simulator. The user provides a coded description of the electronic circuit (a full adder, shown at top), as well as a coded description of the input stimuli desired (in this case, the eight possibilities provided by three binary digits). The simulator produces a list of the binary values at each input and output. The user can then compare the list with the expected response. (A "." means logic 0, a "1" stands for logic 1, and a "?" means logic unknown.)*

verify the design; the complexity and interrelationship of the stimuli are not limited by the availability of signal generators and synchronous interface devices. The fact that the simulator is software based provides each designer with the equivalent of programmable signal generators. The video display of this software breadboard also allows you to monitor as many signals as the screen will display and so is comparable to a multitrace oscilloscope or logic analyzer.

The one major drawback of a software breadboard, however, is the lack of real-time response and diagnosis (i.e., it is a logic *simulator* not an *emulator*). If it is accepted that the primary purpose of the system is validation of *logical* operation and if timing analysis can be postponed until after the logic is verified (a device that doesn't perform the desired logical function is useless), then the impact of this limitation is minimal.

Figure 1 shows the use of a logic simulator for verifying the proper logical operation of a proposed design for a full adder. Each gate is coded as a five-input, two-output gate, with unused "pins" left blank. You assign each external stimulus a unique number (nodes 1, 2, and 3). The output of each gate is also assigned a unique number (nodes 4 through 9). The code for each gate follows the format:

TYPE, IN1, IN2, IN3, IN4, IN5, OUT, OUT-

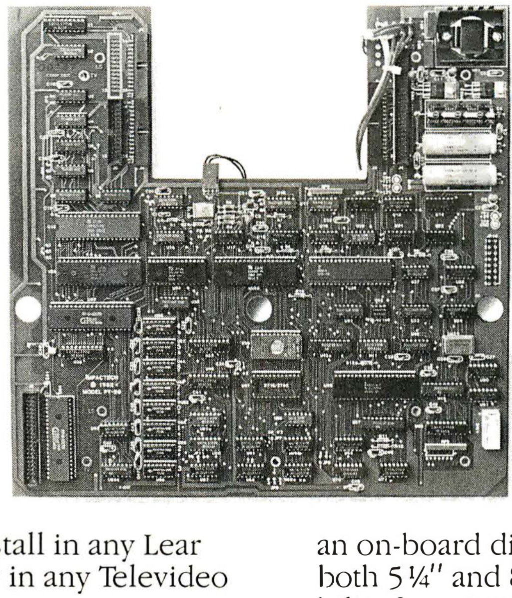
TYPE is the logic-gate type (A = AND, O = OR, X = Exclusive OR), IN1 through IN5 are the node numbers of the signals used as inputs to this gate, and OUT (or OUT-) is the unique number assigned to this node. (If an inverted gate is used, e.g., NAND, NOR, or XNOR, the node number is placed in the OUT- position.) The simulator will simultaneously exercise all gates so that the order in which the elements are entered is irrelevant. The end of the logic description is signaled by a dummy END element.

The simulated circuit in figure 1 is tested by applying each of the eight possible input combinations (000, 001, 010, . . . , 110, 111) and verifying that the SUM and CARRY signals (nodes 5 and 9) produce the outputs required (00, 01, 01, . . . , 10, 11). The coding for scheduling input stimuli is of the format:

NODE,INIT.VAL,INIT.TIME,
CHG T1, CHG T2, . . . ,
CHG T5

NODE is the node number assigned to this stimuli, INIT.VALUE is the initial logic value to be assigned, INIT.TIME is the time to apply the initial value, and CHANGE T1 through CHANGE T5 are the times to "flip" the signal to its opposite value. (If more than five changes are re-

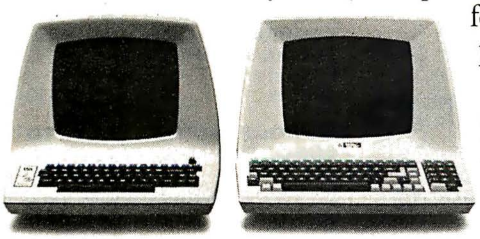
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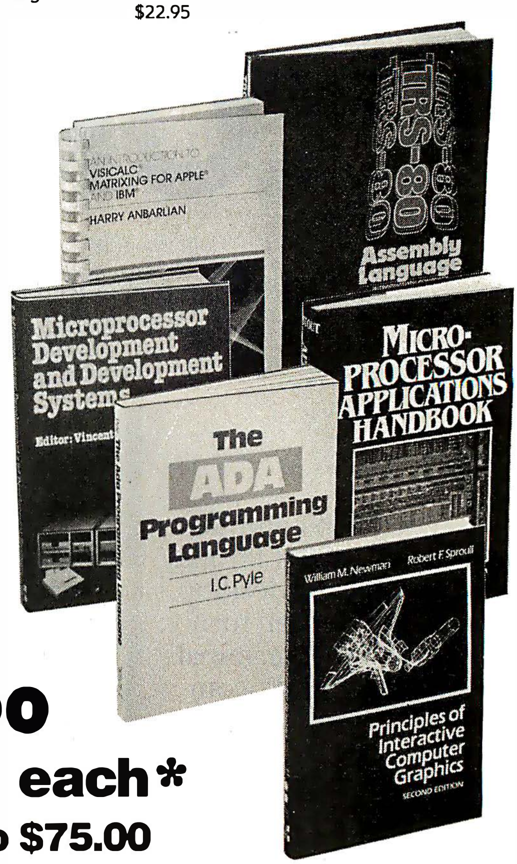
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quired, subsequent lines with this node number are entered.) The end of coding is signaled by a 0 node.

You then enter the signals to be monitored on the resulting timing diagram (nodes 1, 2, 3, 5, and 9), and simulation commences.

An analysis of the output produced by the logic simulator reveals some interesting points. Notice that the outputs are in an unknown state (indicated by a question mark) until driven to a known state. This is one of the significant advantages of logic simulation over hardware breadboarding. A good design should be insensitive to the initial, or power-up, state. In a mass production of a poor design, often some percentage of devices work, but not all. Usually, this is due to differing power-up or default conditions.

An effective logic simulator models at least three states: 0, 1, and "unknown." In the simulator presented here, all nodes are set to the unknown state at the start of simulation and will appear in a known state only when driven unambiguously to that state. (For example, an OR gate will be driven to a logic 1 state when any input is a logic 1, independent of the other, possibly unknown, inputs; similar rules can be developed for other logic gates as well.) Also, the relative time delay for the circuit is shown because the SUM and CARRY signals do not change state until two gate times after the input is applied (corresponding to the two gate delays between the primary inputs and outputs).

The design produces the output you would expect from a full adder, so further analysis is not warranted. Had the output been illogical, internal nodes could be monitored for debugging.

Notice that you can do a complete design, verification, and analysis without physically building the circuit.

The Design of a Logic Simulator

The operation of a logic simulator is similar to that of other time-oriented simulations. In the game of Life, for example, each succeeding generation is determined by the previous generation; typically, two arrays are maintained (old and new) and appropriate rules are applied to transform the old state into a new state. After the entire new state is generated, it becomes the old state and the next new state is generated.

A logic simulator, using predefined logical-gate models, operates similarly by using the old state (current signal values), applying the logical rules associated with the logic gates, and generating the new state (resultant signal values). The simulator departs from the Life-game analogy in the acceptance of stimulations (changes in external signal values) during the simulation.

The application of the logic rule is straightforward for each predefined logic element, particularly if Boolean functions are supported by the programming language. The difficulty in logic simulation is in deciding which signals are to be used for each individual gate and managing signal propagation for signals that drive more than one logic gate.

Fortunately, judicious use of indirect addressing and implicit net-list coding simplifies this task considerably. (A net list is a representation of the interconnection of logic elements. An *explicit* net list is a specific list of each "wire" connecting the elements, as used in instructions for building kits; an *implicit* net list is a representation from which an explicit net list can be deduced, as used when building kits from a schematic.)

If each signal is given a unique number, and this same number is used regardless of where the signal fans out, this number can be used to "point" to the value associated with the signal in the old and new state arrays. When a signal is coded as an input to a gate, the value in the old state array is used; when the signal appears as an output, the resultant signal value is stored in the new state array. This structure also allows for easy transferring of new to old, in that there is a one-to-one correspondence between arrays.

You can implement the addition of



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Listing 1: *The Logic Simulator program written in BASIC for the TRS-80. The program has fewer than 200 lines and requires only 6K bytes of memory. The array space required for most simulated circuitry is about 20 bytes per gate and 3 bytes per stimulus change.*

```
10 DEFINT A-Z
20 CLS
30 PRINT "A BASIC LOGIC SIMULATION SYSTEM"
40 '   R.MCDERMOTT              3/26/81
50 '
60             '  ******  DATA STRUCTURES   ******
70 N9 = 100                 'MAXIMUM NODES
80 N8 = 30                  'MAXIMUM EXTERNALS
90 DIM L(7,N9)              'LOGIC ELEMENT ARRAY
100 DIM E(7,N8)               'EXTERNAL STIMULI ARRAY
110 DIM M(10)                 'MONITOR SIGNAL ARRAY
120 DIM O(N9)               'OLD SIGNAL VALUE ARRAY
130 DIM N(N9)               'NEW SIGNAL VALUE ARRAY
140 DIM X(6)                'TABLE LOOKUP FOR XOR GATE
150 '
160             '  ******  VARIABLES USED   ******
170 L0 = 0                    'INTERNAL REPRESENTATION OF LOGIC 0
180 L1 = 3                  'INTERNAL REPRESENTATION OF LOGIC 1
190 U  = 1                  'INTERNAL REPRESENTATION OF LOGIC UNKNOWN
200 I(L0) = L1              'INVERT (COMPLEMENT) OF LOGIC 0
210 I(L1 ) = L0             'INVERT (COMPLEMENT) OF LOGIC 1
220 I(U)   = U              'INVERT (COMPLEMENT) OF LOGIC UNKNOWN
230 X(L0 + L0) = L0         'TRUTH TABLE FOR XOR
240 X(L0 + U) = U
250 X(L0 + L1) = L1
260 X(L1 + U) = U
270 X(L1 + L1) = L0
280 S$(L0) = "."            'SYMBOL PRINTED FOR LOGIC 0
290 S$(L1) = "1"            'SYMBOL PRINTED FOR LOGIC 1
300 S$(U)  = "?"            'SYMBOL PRINTED FOR LOGIC UNKNOWN
310 F = 0                   'END OF PAGE FLAG
320 E9 = 0                  'ERROR FLAG
330 P = 0                   'CURRENT PRINT LINE
340                         'N1 = LAST ELEMENT, N2 = LAST EXTERNAL
350                         'N3 = HIGHEST NODE #
360                         'L$ = ALPHA CODING OF LOGIC TYPES
370             '  ******  READ LOGIC CODING   ******
380 I = -1
390                         'FROM L(.,0) THRU L(.,N1)
400 PRINT "INPUT CIRCUIT DESCRIPTION"
410 I = I + 1
420 IF I > N9 THEN GOTO 1860 ' CHECK FOR ARRAY OVERFLOW
430 INPUT L$,L(1,I),L(2,I),L(3,I),L(4,I),L(5,I),L(6,I),L(7,I)
440 IF L$ = "END" THEN GOTO 490         'CHECK FOR END
450 GOSUB 1770              'CHECK FOR VALID TYPE, PUT INTO L(0,I)
460 IF L(0,I) = 0 THEN GOSUB 1900
470 IF N3 > N9 THEN GOSUB 1880
480 GOTO 410
490 N1 = I - 1
500 '
510             '  ******  READ IN EXTERNAL STIMULI   ******
520 I = -1
530 PRINT "INPUT CIRCUIT STIMULI"
540 I = I + 1
550 IF I > N8 THEN GOTO 1930  'CHECK FOR MEMORY OVERFLOW
560 INPUT E(0,I),E1,E(2,I),E(3,I),E(4,I),E(5,I),E(6,I),E(7,I)
570                         'CHANGE INITIAL VALUE TO INTERNAL FORMAT
580 E(1,I) = U
590 IF E1 = 0 THEN E(1,I) = L0
600 IF E1 = 1 THEN E(1,I) = L1
610 IF E(0,I) <> 0 THEN GOTO 540        'CHECK FOR END
620 N2 = I - 1
630             '  ******  READ IN MONITOR POINTS   ******
640 PRINT "PLEASE ENTER POINTS TO BE DISPLAYED,"
650 PRINT "(UP TO 10, 0 TO END)"
660 FOR I = 1 TO 10
670 INPUT M(I)
680 IF M(I) = 0 THEN GOTO 700
690 NEXT I
700 'ANY INPUT CHECKING WOULD GO HERE
710 ' ******  DONE WITH INPUT PROCESSING, STOP IF ERRORS   ******
720 IF E9 <> 0 THEN STOP
730 ' ******  INITIALIZE FOR SIMULATION (SET ALL NODES UNKNOWN)
740 FOR I = 0 TO 100
750 O(I) = U                'OLD VALUE ARRAY
```

Listing 1 continued on page 406

external stimuli during simulation by scheduling changes to occur at specific times during the simulation. The use of two arrays, old and new, implies a *unit delay*: each output from the old state array appears one cycle later as in the new state array. This unit of time is typically referred to as a *gate time*. If the simulator keeps track of the gate times, then the external stimuli can be applied (by putting its input value into the new array) just prior to the scheduled gate time for this change. Because unique numbers are used for each signal, each stimulus value will remain constant between changes. Hence, only scheduled changes need to be specified and stored: only a single 1 is stored for a signal that is continuously high.

The display of resultant logic values is trivial; the program needs only to look at selected signals in the new state array and convert the logic values stored there to human-readable form. With graphics available on most microcomputers, the display can be made to look like an oscilloscope's output, a logic analyzer's output, or merely a truth table representation.

A BASIC Logic Simulator

Listing 1 and the flowchart in figure 2, demonstrate the feasibility of implementing a logic simulator on a home computer. The program itself requires less than 6K bytes of memory, and the array storage requirement for a typical design using 100 logic gates and 150 external stimuli changes is less than 3K bytes, so that a complete system is easily implemented in a TRS-80 with 16K bytes of memory.

Listing 1 shows the array requirements, followed by the internal values used for logic 0, 1, and ? and their inverses. I made this particular choice of internal values (0, 3, and 1) to allow the use of the standard AND and OR functions (or MIN and MAX) while maintaining the proper interpretation and propagation of logic unknown states. In other words, for a two-input AND gate, if one input is logic unknown (internal value 1) and the other is a logic 0 (internal value

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Listing 1 continued:

```
760 N(I) = U                  'NEW VALUE ARRAY
770 NEXT I
780 G = -1
790             ' ******  MAIN LOOP FOR SIMULATION  ******
800 G = G + 1
810                           ' UPDATE ANY SCHEDULED STIMULI
820 GOSUB 1000
830                           ' MOVE NEW TO OLD
840 FOR I = 1 TO N3
850 O(I) = N(I)
860 NEXT I
870                           ' PERFORM LOGIC FUNCTIONS
880 GOSUB 1150
890                           'PRINT OUT OLD ARRAY, FLAG END OF SCREEN
900 GOSUB 1510
910 IF F <> 1 THEN GOTO 800
920                           'END OF SCREEN, WAIT FOR INPUT
930 PRINT "CONTINUE ?(YES, NO, OR RESTART (Y,N,R))"
940 INPUT A$
950 IF A$ = "Y" THEN GOTO 800
960 IF A$ = "R" THEN GOTO 640
970 STOP
980             '******  SUBROUTINES  ******
990             '******  UPDATE STIMULI ******
1000 FOR I = 0 TO N2
1010                          'CHECK SCHEDULED TIMES
1020 FOR J = 2 TO 7
1030 IF G <> E(J,I) THEN GOTO 1110
1040                          'GOT A MATCH ON TIME, GET SIGNAL NUMBER
1050 X = E(0,I)
1060                          'FLIP OR INITIALIZE
1070 X1 = N(X)
1080 N(X) = I(X1)
1090                          'CHECK FOR INITIALIZE
1100 IF J = 2 THEN N(X)=E(1,I)
1110 NEXT J
1120 NEXT I
1130 RETURN
1140            '******  PERFORM LOGIC FUNCTIONS  ******
1150 FOR I = 0 TO N1
1160                          'DO AND, OR, OR XOR OPERATION
1170 ON L(0,I) GOSUB 1210 ,1290 ,1370
1180 GOSUB 1450     'STORE OUTPUTS
1190 NEXT I
1200 RETURN
1210 Y = L1                   'AND GATE
1220 FOR J = 1 TO 5
1230 X = L(J,I)
1240 IF X = 0 THEN GOTO 1260
1250 IF O(X) < Y THEN Y=O(X)
1260 NEXT J
1270 RETURN
1280            '******  OR GATE  ******
1290 Y = L0
1300 FOR J =1 TO 5
1310 X = L(J,I)
1320 IF X = 0 THEN GOTO 1340
1330 IF O(X) > Y THEN Y = O(X)
1340 NEXT J
1350 RETURN
1360            '******  XOR GATE  ******
1370 Y = U
1380 X1 = L(1,I)
1390 X2 = L(2,I)
1400 IF X1 = 0 THEN GOTO 1430
1410 IF X2 = 0 THEN GOTO 1430
1420 Y = X(O(X1) + O(X2))
1430 RETURN
1440            ' ******  STORE TRUE AND COMPLEMENT OUTPUTS  ******
1450 X = L(6,I)
1460 N(X) = Y
1470 X = L(7,I)
1480 N(X) = I(Y)
1490 RETURN
1500            ' ******  PRINT OUTPUTS  ******
1510 IF P <> 0 THEN GOTO 1620  'HEADER REQUIRED ?
1520                          'PRINT HEADER AND SIGNAL NUMBERS
1530 CLS
1540 PRINT
1550 PRINT "TIME ";G
1560 PRINT "SIGNALS"
```

Listing 1 continued on page 408

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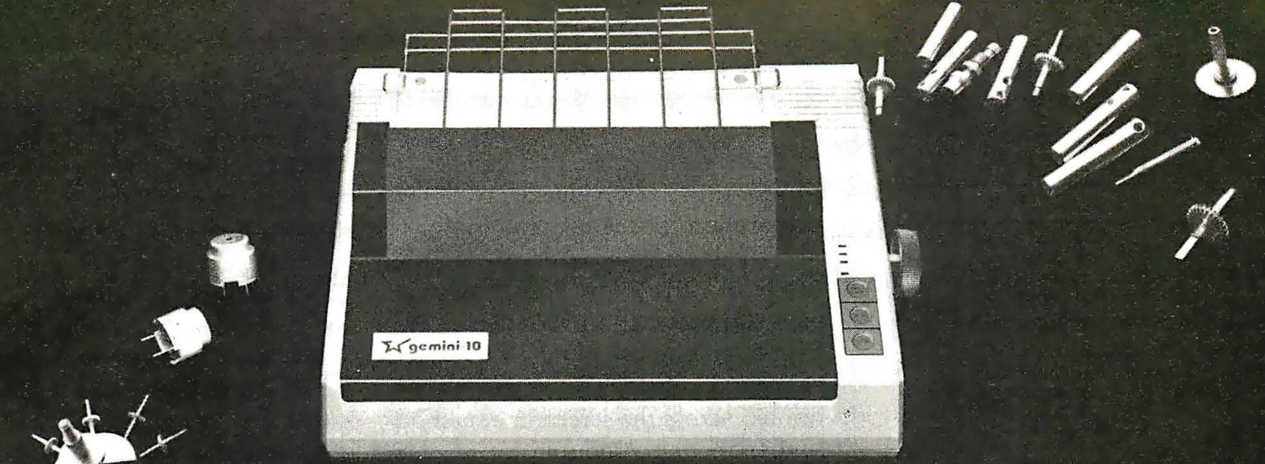
Listing 1 continued:

```
1570 FOR I = 1 TO 10
1580 X = M(I)
1590 IF X <> 0 THEN PRINT @128+64*I,X
1600 NEXT I
1610                         'PRINT SIGNAL VALUES
1620 PRINT @0,"CURRENT GATE TIME ";G;
1630 FOR I = 1 TO 10
1640 X = M(I)
1650 IF X = 0 THEN GOTO 1690
1660 Y = O(X)
1670 PRINT @128+5+64*I+P,S$(Y);
1680 NEXT I
1690                         'CHECK FOR END OF PAGE
1700 F = 0
1710 P = P + 1
1720 IF P < 59 THEN RETURN
1730 P = 0
1740 F = 1
1750 RETURN
1760                '******  GET LOGIC TYPE  ******
1770 L(0,I) = 0
1780 IF L$ = "A" THEN L(0,I) = 1  'AND GATE
1790 IF L$ = "O" THEN L(0,I) = 2  'OR GATE
1800 IF L$ = "X" THEN L(0,I) = 3  'XOR GATE
1810 FOR J = 1 TO 7
1820 IF L(J,I) > N3 THEN N3 = L(J,I)
1830 NEXT J
1840 RETURN
1850                '******  ERROR PROCESSING  ******
1860 PRINT "TOO MANY LOGIC ELEMENTS (";I;") CHANGE N9 (";N9;")"
1870 STOP
1880 PRINT "NODE NUMBER INVALID (";N3;") RE-ENTER"
1890 RETURN
1900 PRINT "INVALID LOGIC TYPE (";L$;") RE-ENTER"
1910 I = I -1
1920 RETURN
1930 PRINT "TOO MANY STIMULI (";I;") CHANGE N8 (";N8;")"
1940 STOP
```

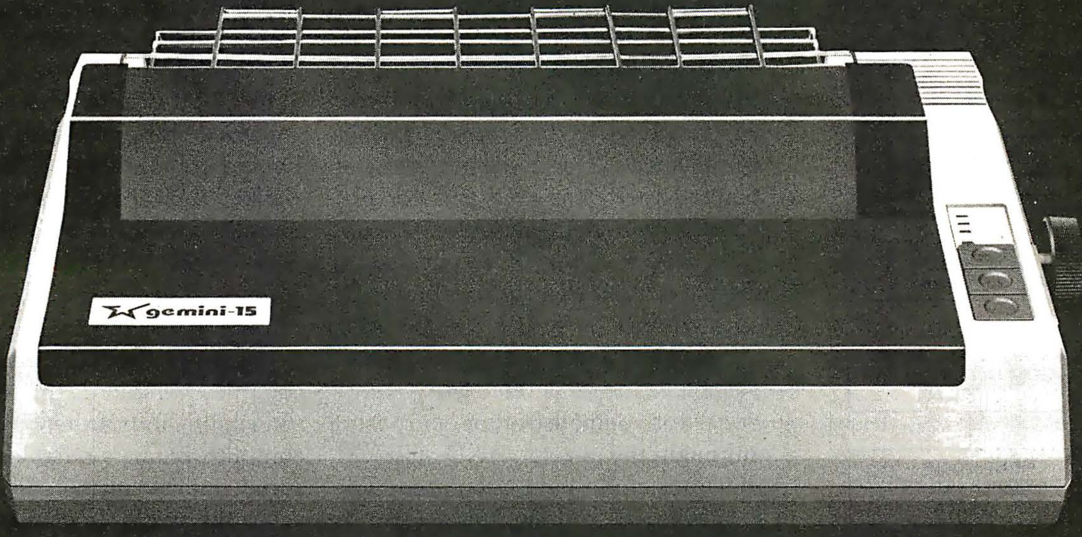
0), the AND (or MIN) function applied to these values will produce a 0, as expected; if a ? and a 1 (internal 1 and 3) are combined by an AND or MIN function, an unknown is produced. The inverse of the values 0, 3, and 1, however, is not equivalent to a NOT function, and explicit coding of the inverses is specified (the I array).

Lines 390 through 680 provide the code for reading the logic description, external stimuli, and monitored signals from the keyboard into the L, E, and M arrays. (Note: to reduce recoding of a design, you could place the logic description and external stimuli in DATA statements and replace the INPUT statements with READ statements.) Elementary error checking (array overflow, invalid logic gates, etc.) is performed as the data is read in; additional checking (wired output gates, undefined inputs, etc.) could be added to assist in debugging.

If the simulator detects no errors, simulation commences; all nodes are initially set to a logic unknown at



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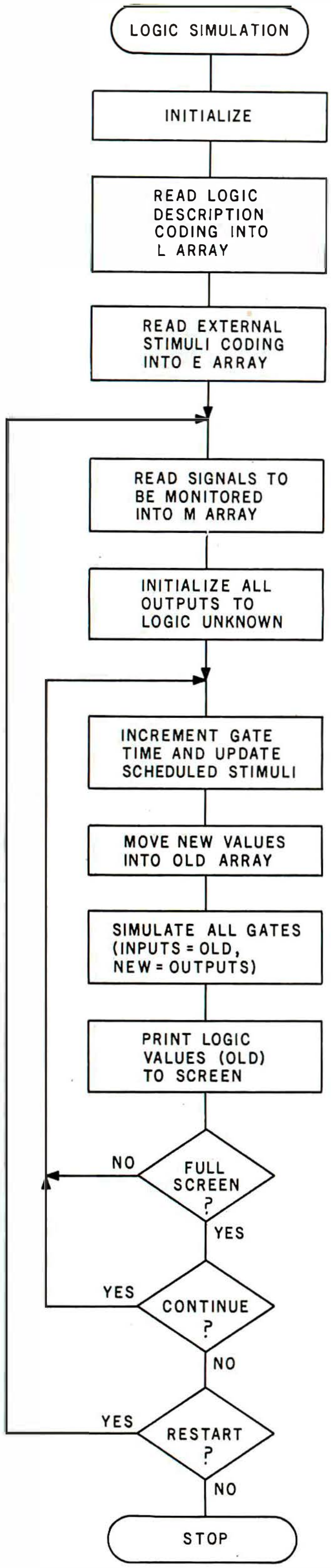


Figure 2: *Flowchart of the Logic Simulator program. The simplicity of this diagram should lend encouragement to those interested in simulating digital logic circuitry. The implementation of this program in a high-level language (see listing 1) can be quite short.*

lines 730 through 760. The external stimuli array (E) is then searched (see line 990) for a scheduled initial value or change and scheduled inputs are placed in the new value array (N) in preparation for the new to old transfer. The logic values currently stored in the old array (prior to the actual gate simulations) are printed to the TRS-80 screen; use of the PRINT @ command allows the values to be printed across the screen in a method similar to that produced by a logic analyzer.

Each logic gate is then simulated, using the logic values in the old array (pointed to by the node numbers) as inputs. The ON. . .GOSUB command at line 1160 branches to the appropriate logical function routine. These functions each put the resultant (true) output in variable *Y*, and lines 1470 through 1510 store *Y* and its complement *I(Y)* in the new array as pointed to by the true and complement output node numbers (an unused output, node 0, merely causes the unused zeroth array location to be overwritten).

The AND and OR routines are implemented as MIN and MAX functions for demonstration purposes, although the logical AND and OR functions could have been used. The Exclusive OR routine uses a form of "table lookup": the sum of the inputs points to the appropriate logic output (array X).

After simulating all gates, the program loops back to process the next time interval, getting scheduled stimuli, printing values, and simulating gates. After filling the screen, the program prompts for a user input before continuing.

Note that this fixed time delay between input and output provides for an apparent "simultaneous" simulation of all gates and also allows for the simulation of sequential devices (flip-flops, counters, etc.) as well. Figure 3 shows a design of a JK flip-flop using a combination of NAND and inverter gates with feedback. The NAND gates are coded as AND gates with inverted outputs; the inverter is coded as a single input NAND. The output demonstrates the simulator's ability to accurately model sequential devices such as cross-coupled gates used as latches; as such, this simulator is capable of modeling any digital system, subject only to the restraints of the memory available for array storage. Variables *N8* and *N9* can be changed to customize the program for added elements or stimuli.

Advanced Simulation Techniques

The Logic Simulator program in listing 1 is provided for demonstration and use for relatively simple designs. It can be greatly enhanced in a few key areas: higher-level models, improved speed, and flexible output.

Higher-level models: Certain medium- and large-scale integration logic devices have become as standard as basic small-scale integration logic gates, specifically D and JK flip-flops, 4-bit counters, etc. A simulator intended for practical applications should contain these elements as predefined logical blocks. If you want to simulate tri-state devices, a fourth logic state (high-impedance) must also be added and models for transmission gates and buses provided.

Improved speed: Obviously, a compiled version of the program will run significantly faster; but even if a compiler is not available, significant speed improvements can be realized using the principle of *selective trace*. Selective trace is premised on the observation that a gate's output will not change state unless at least one of its inputs changes. A coarse implementation of this concept could be added directly to the Logic Simulator program by setting a flag if, while changing the new array to the old array, you notice that any signal changes value. Simulation of all the gates could be performed only if this flag is set.

The decrease in time to perform simulation will be dependent upon the relative activity in the circuit, but decreases of as much as 50 percent could be realized for typical designs. A complete implementation of the selective-trace concept could reduce run times by an order of magnitude; but this method requires that a drive table or fan-out list be maintained for each node. When the node changes state, the elements driven by this

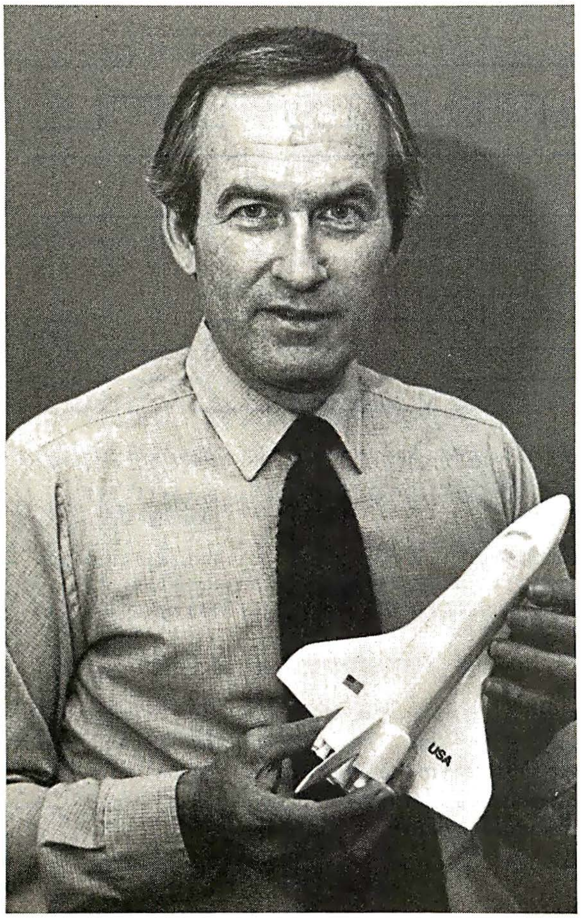
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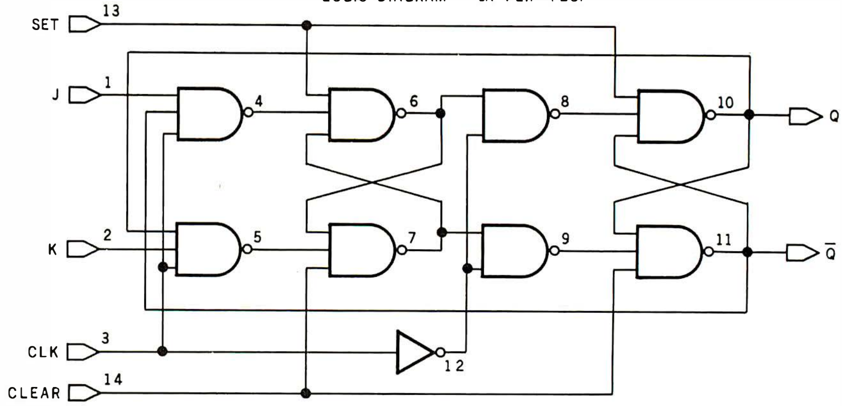
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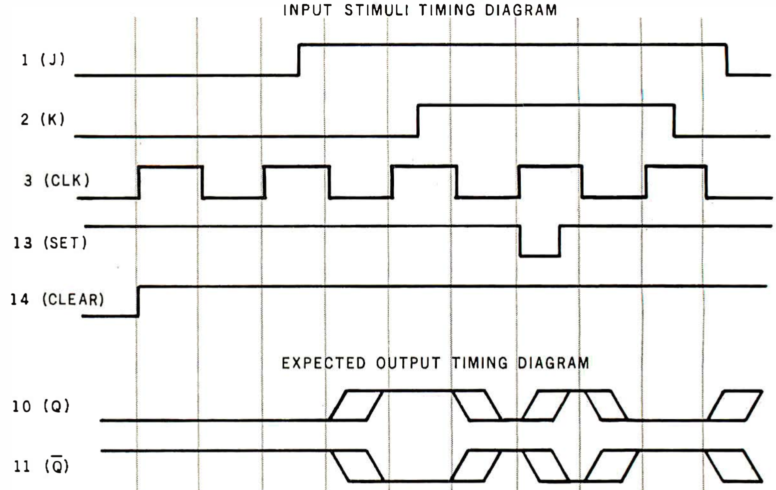


LOGIC DESCRIPTION TO SIMULATOR

```
A  , 11,  1,  3,   ,   ,   ,  4
A  ,  3,  2, 10,   ,   ,   ,  5
A  ,  4,  7, 13,   ,   ,   ,  6
A  ,  6,  5, 14,   ,   ,   ,  7
A  ,  6, 12,   ,   ,   ,   ,  8
A  , 12,  7,   ,   ,   ,   ,  9
A  ,  8, 11, 13,   ,   ,   , 10
A  ,  9, 10, 14,   ,   ,   , 11
A  ,  3,   ,   ,   ,   ,   , 12
END,,,,,,,,
```

INPUT STIMULI CODING

```
1 ,  0,  0, 18, 52,999,999,999
2 ,  0,  0, 27, 48,999,999,999
3 ,  0,  0,  5, 10, 15, 20, 25
3 ,  0, 30, 35, 40, 45, 50, 55
13,  1,  0, 35, 38,999,999,999
14,  0,  0,  5,999,999,999,999
0,,,,,,,
```



SIMULATOR OUTPUT (INPUT AND OUTPUT NODES)

```
1     .................1111111111111111111111111111111111...
2     ..........................111111111111111111111.......
3     ....11111.....11111.....11111.....11111.....11111.....
13    1111111111111111111111111111111111...11111111111111111
14    ....11111111111111111111111111111111111111111111111111
10    ???...................11111111111..11111111.........11
11    11111111111111111111111.........11111.....11111111111.
```

Figure 3: *Simulation of the logic of a JK flip-flop. The design uses simple NAND and inverter gates and is presented to the simulator in the same way as in figure 1. The success of this model demonstrates the simulator's accuracy with sequential systems. (Cross-coupled gates used as latches present no problem.)*

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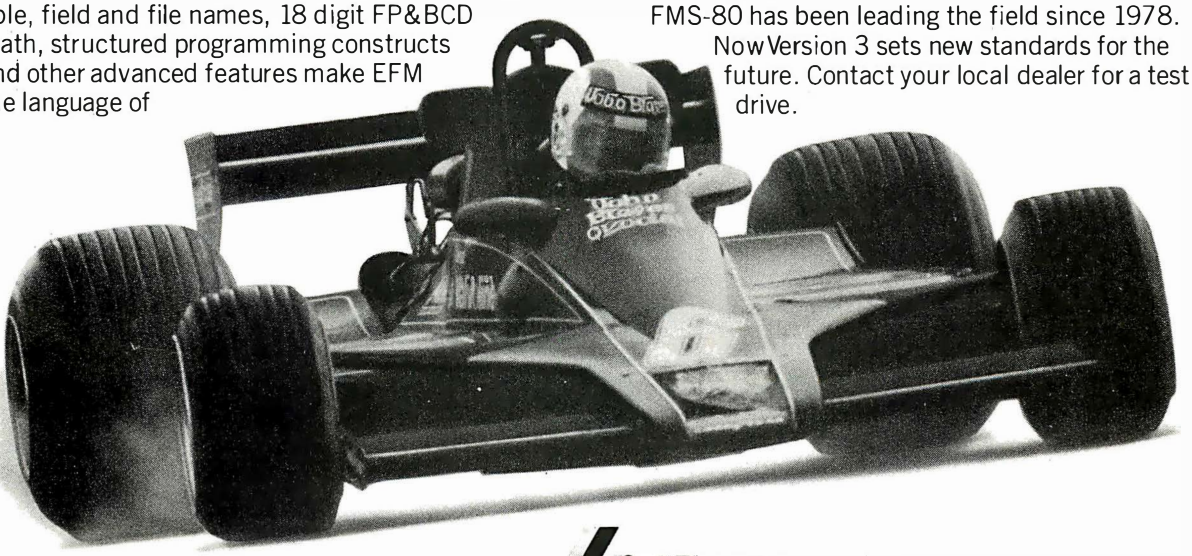
FMS's capabilities go way beyond other data manipulation programs. More fields per record, more open files, more variables, more everything.

	FMS	dBASE	Condor
Maximum fields per record	255	32	127
Maximum number of variables	281	64	0
Maximum number of open files in a program	19	2	2
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Maximum display pages per record	255	3	1

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```
SIGNALS

ENA         .........111111111111111111111111111111111111111111111111
RES         11111..11111111111111111111111111111111111111111111111111
CLK         .1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.
Q1          ?????......11..11..11..11..11..11..11..11..11..11..11..11
Q2          ?????........1111....1111....1111....1111....1111....1111
Q3          ?????............11111111........11111111........11111111
Q4          ?????....................1111111111111111................
```

Figure 4: *Example of a modified output format. In this listing, the simulator printed the output values from a counter every 10 gate times.*

node are flagged, and only flagged elements are simulated on the next pass. (The overhead for this marking and tracing can offset the time gain for small circuits, but larger designs [with more than 50 elements] will show significant gains.)

Flexible output: The format of the output can be modified to provide a sweep control, similar to the sweep control on an oscilloscope, which selects from a range. A global view of the proper operation of the design can best be accomplished by sampling the outputs at periodic intervals instead of producing an output at each gate time. Figure 4 shows the output of a counter circuit sampled every 10 gate times, at half the clock (node 1) frequency, producing the traditional display of the logical operation of a 4-bit counter stepping through its 16 states (nodes 10 through 13 are the outputs of each stage of the counter).

With a system incorporating the above enhancements, plus a few cosmetic changes (named signals rather than numbers, stored output, and hard copy), a logic designer would have a system comparable to those used at professional design centers, albeit slower than most; but time is usually not a critical factor for personal computer users. The savings in time compared to the time that would be spent building and debugging a hardware breadboard far outweigh the time required to perform the simulation (typically a few minutes for a circuit of 50 nodes and 1000 gate times).

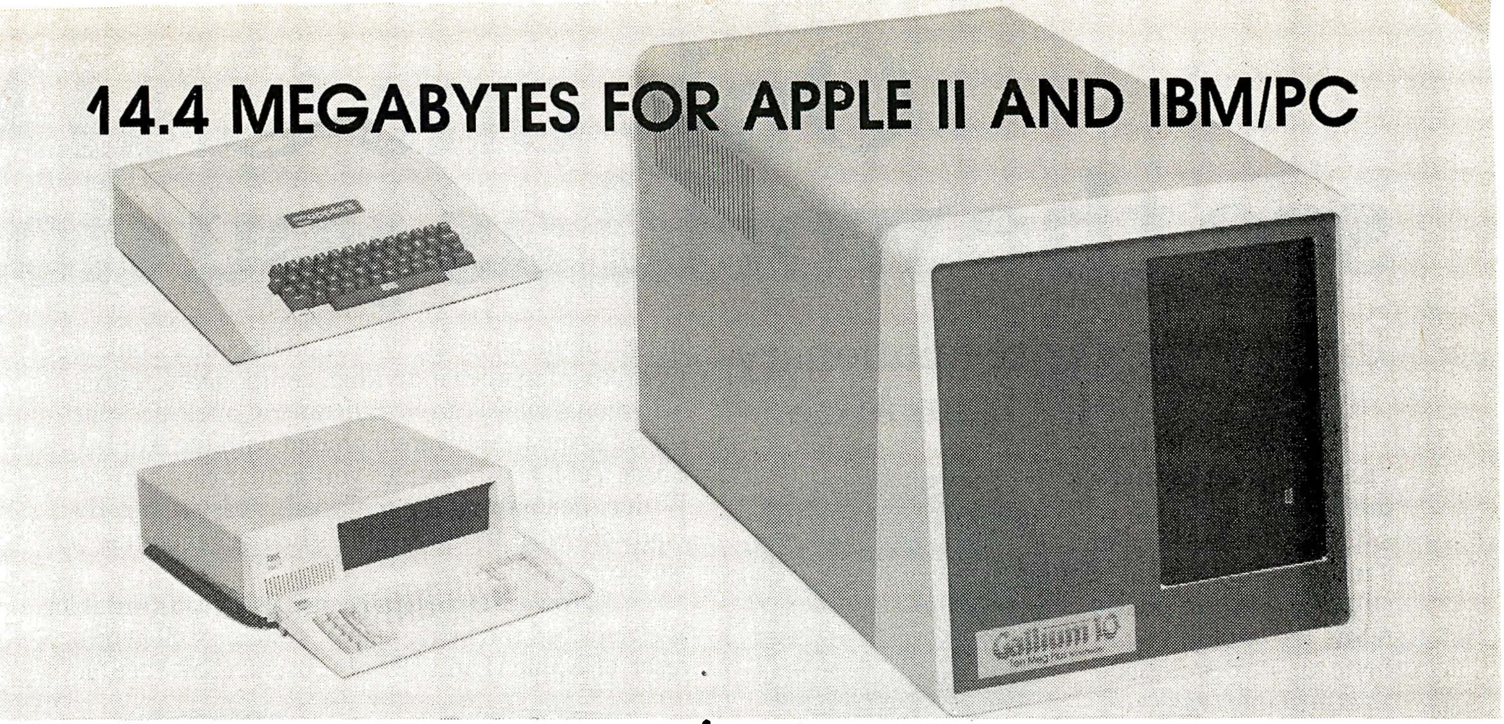
A student can get the hands-on experience required for an understanding of the operation of digital gates and devices through this program. My 10-year-old son now has a thorough comprehension of the function of the basic logic gates and is beginning to get a feel for the concept of sequential devices. ■

Logic Simulator Program

The author plans to make available to interested experimenters copies of the program presented here, as well as an advanced version. The price is $20. Please respond to:

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14.4 MEGABYTES FOR APPLE II AND IBM/PC



PRICE:	**2495.00** complete subsystem for Apple II or IBM-PC
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GALLIUM SOFTWARE

For Apple II, the ROM resident software interfaces to DOS 3.3, CPM and PASCAL operating systems. All operating systems remain unmodified so there is no need to make any program changes when using the Gallium. Any system can be booted directly from Gallium.

For IBM-PC, a connect program is provided which brings the Gallium-10 on line and becomes accessible as Drives C and D.

APPLE

UTILITIES

- Format . . . . Formats all Surfaces
- Volume Initer . . . . Initializes With An "EMPTY" File A Given Number of Volumes in Single, Double or Triple Size DOS 3.3 Volumes
- File Finder . . . . Finds All Volumes On Which Any Given File Is Resident
- File Runner . . . . Finds & Runs The Given File From the First Volume On Which It Is Resident
- Partition . . . . Partitions The Disk For DOS 3.3, CPM & PASCAL Allocating The Required Number Of Sectors For Each Given Operating System
- Connect . . . . Connects Gallium To DOS If Booted From Floppy Disk

IBM

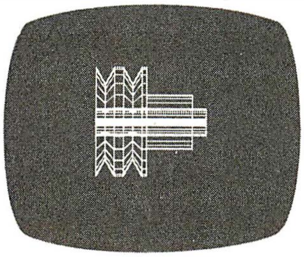
UTILITIES

- FDISK . . . . Formats All Surfaces, Once Formatted Capacity is 11.5 Megabytes
- DSKLNK . . . . Connects Gallium to PC-DOS
- CHKHRD . . . . Similar to PC-DOS CHKDSK Utility, Reports Disk Usage

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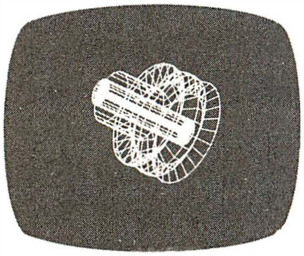
Only one CAD see the world as you do

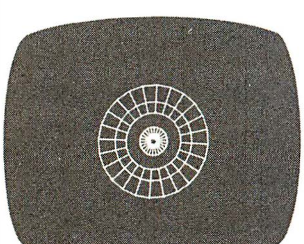
Introducing the revolutionary Space Tablet™ from MCS.



"Experts" told us that interactive, 3-dimensional graphic design on a microcomputer was still only a future possibility. We couldn't wait. Instead, we developed an affordable, easy-to-use graphics system that can construct and manipulate drawings in 3-dimensional space . . . the Space Tablet.

An added dimension. Like other digitizing systems, the Space Tablet (patent pending) lets you plot and record X and Y coordinates on a two-dimensional plane. But unlike other systems, it also lets you select points off the plane — along the Z axis — for a true 3-dimensional capability.

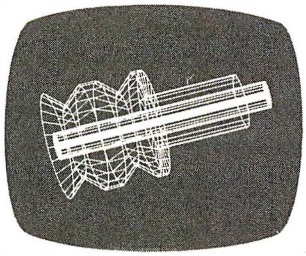


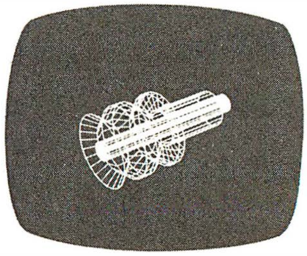


To digitize any point in space, just move the Space Lift™ arm to the desired location and record the point with the push of a button or key. That's it. Lengthy keyboarding operations are unnecessary. Points plotted in the X, Y and Z axes may then be joined with line segments to create a wireframe drawing with three-dimensional perspective. 3-D models can be created by tracing a physical object or an imaginary shape. Here's where the possibilities really begin . . .

Interactive manipulation means total flexibility. The Space Tablet's software packages allow interactive manipulation and editing of points in all three dimensions. *This capability is unique in computer graphics.* Space Graphics™ software for the IBM Personal Computer lets you select a point in space and "pull" it, and all connecting lines, to another location in 3-space. 3-D models can be scaled, rotated and moved about any axis. New models can be composed by linking together individual components. Three orthogonal views can be called up at once in a split screen format. Software included with the Apple II Space Tablet system gives you similar capabilities. With either system, it's remarkably easy to try all kinds of "what if" possibilities before generating hard copy.

Now, 3-D design is surprisingly affordable. We've priced the Space Tablet systems well within reach of Apple II and IBM PC users. (Software for

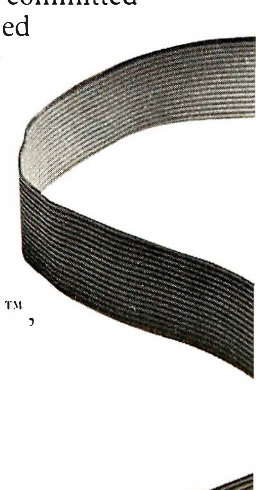




other popular microcomputers will be available soon.) Because it's an entry-level system, the Space Tablet is being used creatively in ways not normally associated with larger, far more costly CAD/CAM systems . . . molecular modeling, physical therapy programming, cell structure analysis, weapons research, medicine, art, architectural planning and, of course, design and engineering. Additional applications are being discovered by OEM purchasers. And, for those needing a 2-dimensional digitizer, the Space Lift arm can be held as a pen, or stylus, to trace slides, X-rays, pictures, graphs, maps and more. We see it as a tool to unleash the imagination.

Our perspective of the world. If the real world were 2-dimensional, conventional design methods would be adequate. Obviously, they're not. Three-dimensional thinking is natural in the development and communication of complex design ideas. That's where MCS comes in. We're committed to the potential of 3-D computer aided design and manufacture. The Space Tablet is the beginning of a revolution in the use of microcomputers to process information and solve problems. And we're just getting started.

A high-resolution 2-D tablet equipped with the Space Lift arm is ready for release. Called Microcad I™,



IBM Personal Computer Minimal Configuration: 128K, game paddle adapter, color/graphics adapter.

Apple II microcomputer minimal configuration: 64K, DOS 3.3.

Burnouts, Bargains, and Two Sleek Portables

The tireless industry critic mourns Ezekial and seeks comfort from the exquisite Adelle, who happens to be an Otrona Attache.

Jerry Pournelle
c/o BYTE Publications
POB 372
Hancock, NH 03449

I've been away from my desk for a month, and things are piled higher than you can believe. As a consequence, this column is going to be a bit disorganized (try total mishmash), and I hope you'll all forgive me.

I'm a bit upset anyway. Poor old Ezekial, my friend who happens to be a Cromemco Z-2, is stacked in the other room, waiting for Nor Singh to take him over to Tony Pietsch's shop for a complete overhaul. While I was gone, John Carr, our long-suffering associate editor here at Chaos Manor, was working on *Space Viking's Return* when Zeke, with no warning at all, simply died. Fortunately, John has been trained to save the text early and often, and little was lost.

I suppose I shouldn't be surprised. Several million words went through Zeke. He was running constantly 18 hours a day for nearly five years, and in all that time he wasn't out of service for more than a week. Moreover, from the description of the problem—he keeps blowing fuses—it may be no more than a blown capacitor in the power supply. Tony is pretty sure he can get Zeke fixed—when he gets time.

What happens to software when your computer dies? . . . If it's legal for you to lend my books to a friend, why can't my computers lend programs to each other?

But time is very much a problem. Tony is doing version 1.7 of WRITE (Writers' Really Incredible Text Editor) for Ashton-Tate, and he has also put together my *new* Compupro that will have memory-mapped video and the new super-nifty keyboards. I wonder if Zeke, hearing about the new writing machine, simply went away like my old black cat did when the kids brought home a kitten? But that's ridiculous.

Anyway, I'm writing this on The Golem, my big Warp Drive Compupro 8085/8088, using the Televideo 950 terminal, and while it's infinitely easier than using a typewriter or a cheap machine, it's also the first time in five years I've done major work without Zeke.

Of course, there have been exceptions. We took the Otrona Attache to Europe, and I had a Kaypro II in Chicago; more on those later.

Good Grief, Zeke Can't Die!

That is: not only is Ezekial my friend, and practically a trademark

(he gets nearly as much mail as I do), but there's the legal problem.

Consider: I have a ton of software running on Zeke. In theory it is licensed for "a single computer system." If Zeke is gone, have I any right to the software? I suppose I should buy it all anew or pay a license transfer fee. Perhaps, though, if Zeke is still connected to the "system"—that is, there he sits, connected into a single "system net" so that I have met the legal requirements—must he be alive? Can a dead computer be part of "a single computer system"?

Obviously I'm not serious. Or am I? Because somewhere along the line we've got to come up with answers to some questions. What *does* happen to software when your computer dies? If you sell the machine, who gets the software? And the solution has to be realistic; I suspect that even those who rail loudest against computer pirates have not actually paid twice for their BASIC (or even transferred the license) after they upgraded from a beginner's machine to something larger.

As for me, I've come to a decision: some of the user-threatening licensing agreements I simply will not sign; and I urge all of you to do likewise. As an author I'm hardly going to quarrel with the idea that programmers and their publishers need protection from pirates; but some of them try for too much, and end with imbecile notions. If it's legal for you to lend (or even give, if you don't copy them) my books to a friend, why can't my computers lend programs to each other?

Ada Now and Always

The chaps at RR Software continue to produce upgrades and updates to the Janus/Ada package. Two revisions appeared while I was in Europe. RR also has an excellent upgrade policy for its early customers.

Randall Brukardt of RR sent me his latest upgrade with a mild complaint: my lament about the high cost of manuals is misguided. He says, "I am afraid that $30 is about the minimum one can charge for a decent-sized manual. Ours now cost $10 to print, gather, and bind (in quantity 500—you don't dare print more manuals than you can use in a year or so). Shipping costs $2. Record keeping, advertising, and other overhead eat up more. And on top of that is the markdown we must give distributors. . . ."

Randall isn't the only one who has that complaint, so perhaps I'd better make my point a bit clearer: I didn't say that one shouldn't charge that high a price for a manual, I said that most manuals I have seen are not *worth* that much.

I don't care what it costs to produce the manual; what it is worth is determined by what's in it, and that's usually pretty poor. I fear that Randall is confusing effort with work, which is a pretty common mistake with programmers, authors, and many others. You've heard it before: "It took me six months to write that. Don't I deserve a decent price for it?" And of course the answer is, "Not necessarily."

I'm also pleased to report that as far as I can determine, RR Software does *not* confuse effort with work. As I said above, it has an excellent record of seeing that its customers get needed

updates and revisions at reasonable costs, and every edition of its manuals has been an improvement. The latest is better organized than the first, and has lots of examples.

If this sounds vague, it's because we still have no Ada experts here at Chaos Manor. However, Alex just got through talking with Randall Brukardt, and help is on the way. It seems RR has a Pascal-to-Ada translator. Alex is going to use that on his Pascal introduction programs, then with the help of some Ada consultants write new programs that illustrate Ada's unique features. When he's done, he'll have an introductory tutorial to accompany the best Ada textbook we can find (which at the moment is still I. Pyle's *The Ada Programming Language*, Prentice-Hall, 1981), and Workman can add it to its best-selling Pascal introductory package. That plus the RR Software Janus/Ada compiler should be more than enough to teach Ada to anyone seriously interested; and as I said in the July 1982 column, learning Ada is one excellent way to guarantee yourself a reasonable job in the future.

I can say this with some confidence, because people whose opinions I respect and who are quite familiar with the RR Janus/Ada compiler are highly impressed with it.

However, fair warning. Some other so-called Ada compilers for microcomputers are so limited as to be crippled. What's the point of learning a strongly typed language with severe limits on the data types you can use? Janus/Ada, though, is a very healthy subset of the real thing.

Are My Old Columns Really Worth It?

Alas, Randall's lament about the cost of producing manuals is not so wide of the mark. Barry Workman tells me that to do a loose-leaf version of "Pournelle on Computers" wouldn't be cheap, and if they're to go to bookstores and such, the discounts make things worse.

My problem is simple: Is a collection of my ramblings, most previously printed in one or another magazine, worth the 20 bucks Barry thinks he'll have to charge? Now true: commercial publishers would put out the book for less. The problem with that is obvious: they'd save by printing a lot of them, which, while more profitable for me, practically guarantees that much of what would be in the book would be obsolete before all the copies were sold. The idea of loose-leaf was to allow revisions as things change.

As of now we're still pondering that dilemma.

Communications

According to the inquiries Barry Workman gets, the world is waiting for a good microcomputer communications system useful to beginners; something that starts by explaining what a modem is and how you might install one, and goes on to tell how to use it.

The problem isn't simple and can confuse experienced computer users. A good public-domain program for microcomputer communications *is* available. Called Modem 7, or XMODEM, it's written by Ward Christensen and is available from the CP/M Users Group. There's only one

problem: a lot of beginners aren't able to get it running. I've had problems with its documents myself, and unless you know something about the internal architecture of your computer, it's nearly impossible to get Modem 7 tailored to your system's needs.

Christensen, as is his ethical right, isn't interested in having someone rework the instructions for beginners and then sell the program; and so far (as I write this, anyway) no one wants to do it for nothing, because each kind of hardware you'd want to install it on needs a different set of instructions (or at least some changes in the old), and there'd also be lots of telephone time spent answering questions.

Of course, anyone has the *legal* right to repackage the program and sell it for anything they want to, and I have horror stories of one firm that sold Christensen's public-domain program to the federal government. It sold some 20 copies at several hundred dollars each (no discount for quantity purchase). A couple of other commercially advertised programs are also clearly based on Christensen's work. Some have decent documentation.

Some years ago, Larry Hughes wrote a program called LINK. It's available for $8 on Disk 19 of the CP/M Users Group. It is now marketed under various names. I suppose that some of those selling it have made improvements, but I'm not certain. LINK was somewhat limited, so Larry wrote a new program called CLINK, which he marketed for a while. That one is also available, with a few modifications, from several companies, at least one of which advertises heavily.

The most painless method I know for getting communications is to buy Larry Hughes' MITE from Mycroft Labs. Hughes has been around microcomputers, including CP/M systems, for a long time. MITE is a very good menu-driven program that will let you send and receive files, link to communications nets such as Compuserve and The Source, and in general do the communications most people would like to do.

MITE does a few things that Modem 7 doesn't do. It lets you get binary (COM) files off other systems that don't speak Modem 7, for instance. It's also much easier for beginners to get MITE running and to operate it after it is running; and Mycroft Labs will assist with problems.

MITE's documentation could be improved, but it's still about the best I've seen, because its purpose isn't to teach you to *install* MITE, but to show you how to use it, and it does that quite well. MITE will let you talk with most university stations; various online CP/M systems, including those running Ward Christensen Computerized Bulletin Board Systems; XMODEM protocols; etc. MITE is compatible with TRS-80 systems running Modem-80 through a conversion program that converts TRS-80 text files into CP/M format.

You can get MITE preinstalled for many systems, including Xerox 820, Televideo TS801, S-100 with PMMI (Potomac Micro-Magic Inc.) modem or Hayes Micromodem, Apple II with Z80 Softcard and Hayes Micromodem II, and Zenith Z-89. You can also get it "uninstalled" and write a communications input/output sys-

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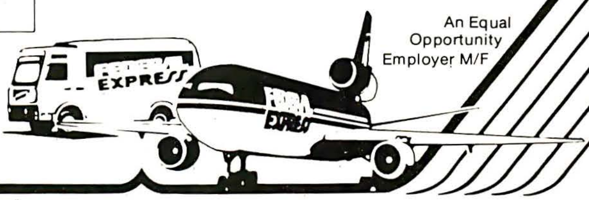
Use sophisticated computer based models and other operations research methods to analyze broad and complex corporate problems and projects. Make recommendations to senior management on best alternatives and provide consultant services on key corporate projects. You may qualify as an Operations Research Analyst if you have a Bachelor's degree in a quantitative discipline such as Math or Computer Science. A Master's degree is preferred. Three years professional experience preferably in Math or Computer Programming is required. Your experience in Operations Research is a definite plus. Naturally you should be proficient in FORTRAN and PL-1.

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tem. If you're up to doing that, however, you may not need MITE since one or another of the public-domain systems could be adequate. Those who don't know a lot about computer communications, though, ought to write Mycroft Labs and find out if there's a version available for their system. It's by far the simplest way to get in touch with the electronic world.

There are good reasons for getting communications, because there's so much cheap—and even free—information available out there in microcomputer land. You only have to know how to get it.

Knowledgeable Promises

It doesn't happen often, but sometimes people send me stuff that I feel guilty about not reviewing. One such package is from Knowlogy. It's been sitting on the "Urgent" shelf for a solid year now. Usually, anything that handsome would have been chosen as a project by one of the troops, but somehow it just didn't happen. Maybe the terminally cute name "Knowlogy" scared them off.

Aside from the name, though, Knowlogy's package is a class act, with some of the most readable documentation I've yet seen in this business.

What Knowlogy sells is a Unix-like shell for CP/M. It's called Unica, and it is supposed to let you use Unix-like commands (some directly from Unix) in operating your microcomputer.

Probably the most desirable feature of Unix is that *everything* is a file. You can direct the output of one process to be the input of another, using imaginary "pipes" to conduct the information.

Knowlogy's Unica preserves this. It also has wildcards (ambiguous file names, such as "JA*.*", which will get every file beginning with the letters "JA"), announcements and verifications, and such like. Programs within the Unica system include file comparators, concatenation, copy, disk map, ways to link files, pattern searches, and more. Each is well documented.

Unica lets you use Unix-like commands on a microcomputer.

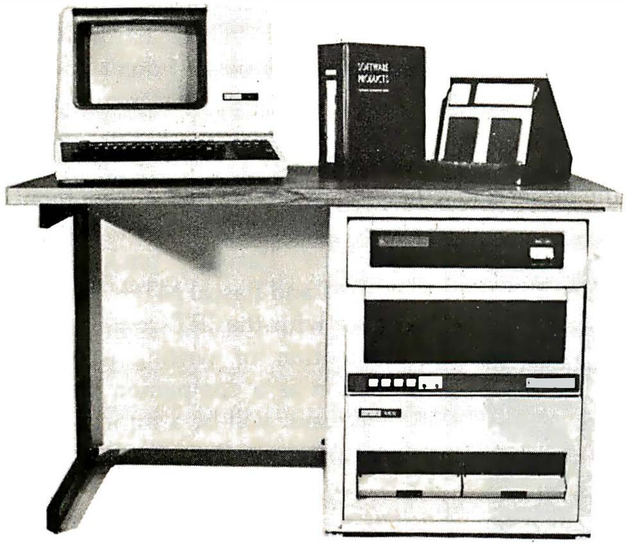
Knowlogy's other product is Unica/XM-80, which is a structured approach to assembly-language programming. To quote from the documentation, "Software synthesis is a methodology which encourages the programmer to design each software module in such a way that it can be used in more than one program. Unica/XM-80 is a programming language which incorporates software synthesis constructs into the Z80 assembly language."

All of Knowlogy's documents are written that way: a bit too polysyllabic, but clear, reasonably precise, and in good English. The claim that Unica/XM-80 is a "language" is a bit strong. From its own documents, it is a preassembler able to translate a number of shorthand notational devices, expand macro instructions, and incorporate previously written routines.

This is not a full review of

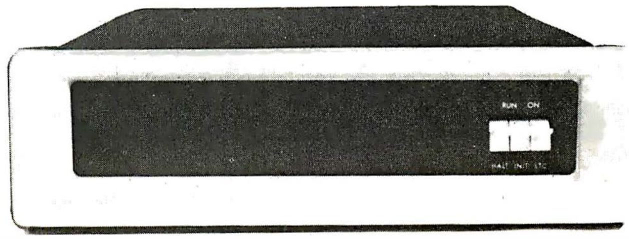
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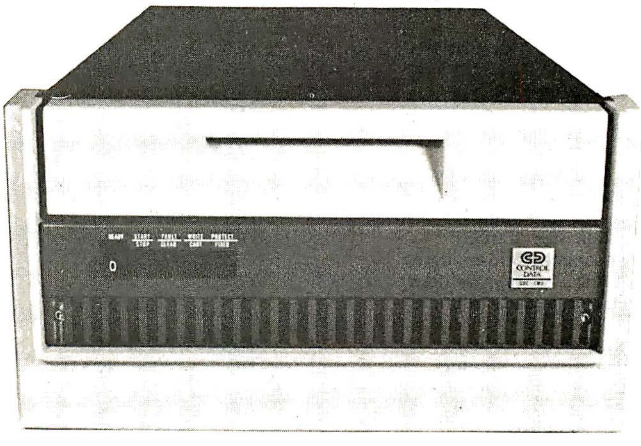


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Knowlogy's package, because we haven't tried it out. Normally, I don't talk about stuff we haven't used here, and I don't intend to break that rule often. The reason in this case is that I have been so impressed with the clarity of writing in the Knowlogy documents that I feel reasonably assured a good job has been done on the rest of the work.

Honorable Mentions

Not long ago, I started an article on software for the masses. We collected a whole bunch of stuff for less than $100, much of it $50 or less.

Three of those items stood out and will get a lot of space in that article. (I'd have it done already except for our vacation. So it goes.)

The first is Walt Bilofsky's Software Toolworks, which we've mentioned here before. Bilofsky has a whole raft of programs that work, and he sells them for reasonable prices. I strongly recommend that you get his catalog.

Second, Comshare Target's Plannercalc, which, although it lacks some of the features of the bigger and more expensive spreadsheet programs, does a heck of a lot for the money. One warning: we have never met anyone able to get Plannercalc running on a CCS (California Computer Systems) machine. It runs fine on our 8085/8088 and Z80s; apparently, there's an interaction between Plannercalc and the CCS, but whether that's CCS hardware or Plannercalc software I don't know.

Finally, there's JRT Pascal, which at less than $50 is a fabulous bargain. JRT Pascal has limits; but it's a lot for the money. We've had it for a month now. Alex, having finally finished his "Intro to Pascal" package for Pascal/M and Pascal MT+, has been working with the JRT compiler with the intention of writing a full introduction as a companion piece for it. The result will be a tutorial, compiler, *Programming in Pascal* by Peter Grogono, and *Software Tools in Pascal* by Brian W. Kernighan and P. J. Plauger for less than $150: a bargain at any price.

Another Problem

I continue to get reports of long delays in getting service for CCS computers. Max, whom I've mentioned before, writes a continuation of his horror story.

Max bought his CCS from a large mail-order discount house. That may have been a mistake, because he knows nothing of computers and lives in upstate New York far from large dealerships and big repair centers. He's working on a very time-dependent project that requires a working computer and dBASE II. His problem involves sending his boards Express Mail in the assurance there would be loaners to replace them, only to find that they'd changed the policy of providing loaners even as his were on the way.

Max concludes, "If I had bought Compupro I could have 48-hour service on the boards. Since Compupro is not twice as expensive as CCS, they are the better buy in the long run."

Certainly, Bill Godbout's Compupro equipment is good stuff, and if anyone asks me, that's what I generally recommend (recall that it's also what I'm most familiar with).




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However, in fairness I have to say that Alex has had no real problems with his CCS, nor has Dr. Possony, and many of my friends are very happy with their CCS systems.

Ours were obtained through Colin Mick of Decision Information Services, and what difficulties we've had have been taken care of quietly and efficiently. We're using Helen—Alex's CCS—to transfer programs and files to and from the Osborne 1, because the CCS can operate both 8- and 5¼-inch drives simultaneously. (So can my Godbout, which writes 5¼-inch disks in the IBM Personal Computer format.) Alex did have some problems adding the little disks, but Colin soon straightened them out.

Now for a Travel Report . . .

I'm writing much of this in Chicago with a thoroughly unfamiliar computer and text editor. Worse, when I do get back home—not too long now—I'll still be using unfamiliar systems (although at least I'll have WRITE to use) because Ezekial is dead.

I'm in Chicago for the World Science Fiction Convention. Before I went to the convention—the traditional science fiction name for these things is "Worldcon"—we spent three weeks in Italy, where I carried the Otrona Attache from Los Angeles to Rome to Venice to Verona to Florence. The Otrona worked splendidly, uncomplainingly chewing up strange voltages and even stranger frequencies. I'd be using it still, except that I stupidly tried to operate it off the converter we use for my wife's hair dryer. That, alas, simply didn't work.

Until I managed to damage it, though, the Otrona was a real delight, and I'm sitting here looking rather wistfully at it and hoping it will be easy to repair.

Since I hate to be without a computer—I simply can't write without one—I had Alex ship me another to catch up with me in Chicago for the Worldcon. Luckily, we had just received an evaluation copy of the Kaypro II, and Alex just had time to get it to me.

It says a lot for the Kaypro that I got it without any documentation whatever, but I'm still able to write this. It isn't that the Kaypro comes without documents, of course; it's just that when Tyler Sperry of Non-Linear Systems brought the Kaypro over to the house a little before I left for Italy, he decided to take it back for some adjustment, leaving the documents in my office; and when it came time for Alex to ship the machine to me, he couldn't find them.

Doesn't matter. I'm using the machine and the Select text editor that comes with it, and I'm not having any real trouble at all.

That surprises me. I am, after all, rather set in my ways, and more than that, I've just tramped all about Europe getting used to the Otrona, which runs Wordstar. Moreover, the Select word-processing editor that comes with the Kaypro looks to be of a type that at first sight I don't like at all, being one of the editors that has various command modes. For all that, I am using it, and am having surprisingly little trouble.

The editor is a little strange, and it will never be my favorite, but by gollies it does work. It is a full-screen editor, with the ability to let you

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drive the cursor around and do things to the text. (I've just inserted this sentence after finishing the page. That works fine.) You have to go into Insert mode to actually write, and into a Command mode to do anything else (including moving the cursor). Creating text is therefore easier than editing it. It also has the misfeature I like least about Wordstar, namely that every time I hit a key there's a flicker at the top of the page as the editor informs me what line and column I'm at. For all that, Select is surprisingly easy to work with.

(Flash added back home in California: the Select documents tell you how to turn off the status line with its flicker. Hurrah! Now back to Chicago.)

Learning Select is a snap. It's nearly self-explanatory anyway, and there's a long Teach program that does the job also. If I seem to be rambling a bit, I am; I'm learning about the machine even as I write this, and I hope you'll all have patience because this column is due the instant I get home, and there's nothing else to write about just now.

I'll undoubtedly have more to say about Select later; for now, my impression is that it wouldn't be my first choice, but it's at least as easy to use as Wordstar (so far; but I haven't done anything really tricky yet). It is by all odds the easiest editor to learn I've ever seen. I just sat down to it and started using it. Of course, I have *some* idea of what to expect from a text editor, but even so, I'm impressed.

Now that I've gone back and done some editing, I'm a little less happy with Select. For one thing, every time you insert something—anything, even a space—you then have to leave the Insert mode before you can move the cursor and type anything else. Before you can do that, though, the machine wants to rejustify your text, and it does it without your asking it to. Alas, it takes a while. However—and this is important—it takes a while only in comparison with machines a lot more expensive than the Kaypro II.

(Another flash from the home front: the documents tell you how to turn off that feature as well, so that you can write away and globally reformat the text once and for all when you're finished. I like the Select approach of letting you have choices about things like that.)

Leave the editor, then, with the bottom-line comment that it will do. Let's look at the computer itself.

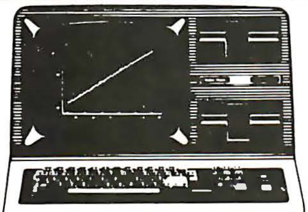
The Kaypro II uses a Z80 chip and has 64K bytes of memory. It comes all up; that is, there's a computer, keyboard, and video screen all included in the price. Kaypro II, from Non-Linear Systems, is intended to compete with Adam Osborne's Osborne 1 and is priced accordingly. CP/M, the Select editor, a spreadsheet program I haven't had a chance to try, and a *compiling* BASIC called SBASIC are included. The most impressive part of the package is the machine itself.

First, it's handsome enough. It comes in a metal case, with clips to hold the keyboard. The power cord and the telephone-curly cable to the keyboard coil about some jigs on the back of the machine and can be put pretty securely in place. The handle is

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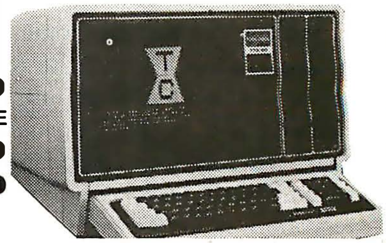
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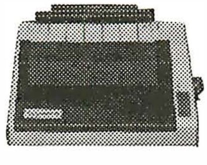
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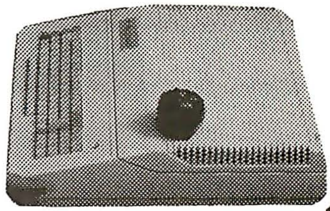
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also back there, so that you carry it with the keyboard, cables, and plugs all exposed. I've suggested that they'd be better off making a cover that the handle could stick through, and I understand they offer one as an option.

The machine comes with dual single-sided double-density 5¼-inch disks, and it boots up on CP/M 2.2x on power-up or reset. This one, having been shipped by UPS to Chicago, came up instantly on being turned on.

(Now back home to California to finish this. If this text is in the column, you'll know I was able to transfer from the Kaypro to the Compupro.)

I brought the Kaypro home on the airplane. Indeed, I had the Kaypro and the Otrona, two large suitcases, a briefbag, and a hanging garment bag—I felt sorry for the people who had to board just behind me, but everyone was very nice. I can therefore testify that you can put a Kaypro II into an aircraft overhead rack and get the rack door closed. It's a close call, but it can be done. It will also fit under an aisle seat.

I had to change planes in Denver, so the Kaypro got a complete exposure to aircraft hazards, went through security twice, and was hustled along airport corridors by a man with far too much luggage. Even so, it booted up first crack on getting home, and I'm working with it now.

The Kaypro has a large screen, certainly the largest screen you'll ever get in a portable machine.

Thus, it's certainly rugged. It has other things to like, too. The keyboard is full size and is a full ASCII (American Standard Code for Information Interchange) character-set keyboard, complete with squiggle and curly braces and such like, as well as a numeric keypad and four cursor arrow keys. The key layout is more or less Selectric style. The Shift keys are oversize and in the right places, the Return key is suitably large and placed near the home keys, and I've had absolutely no problems touch-typing on the machine.

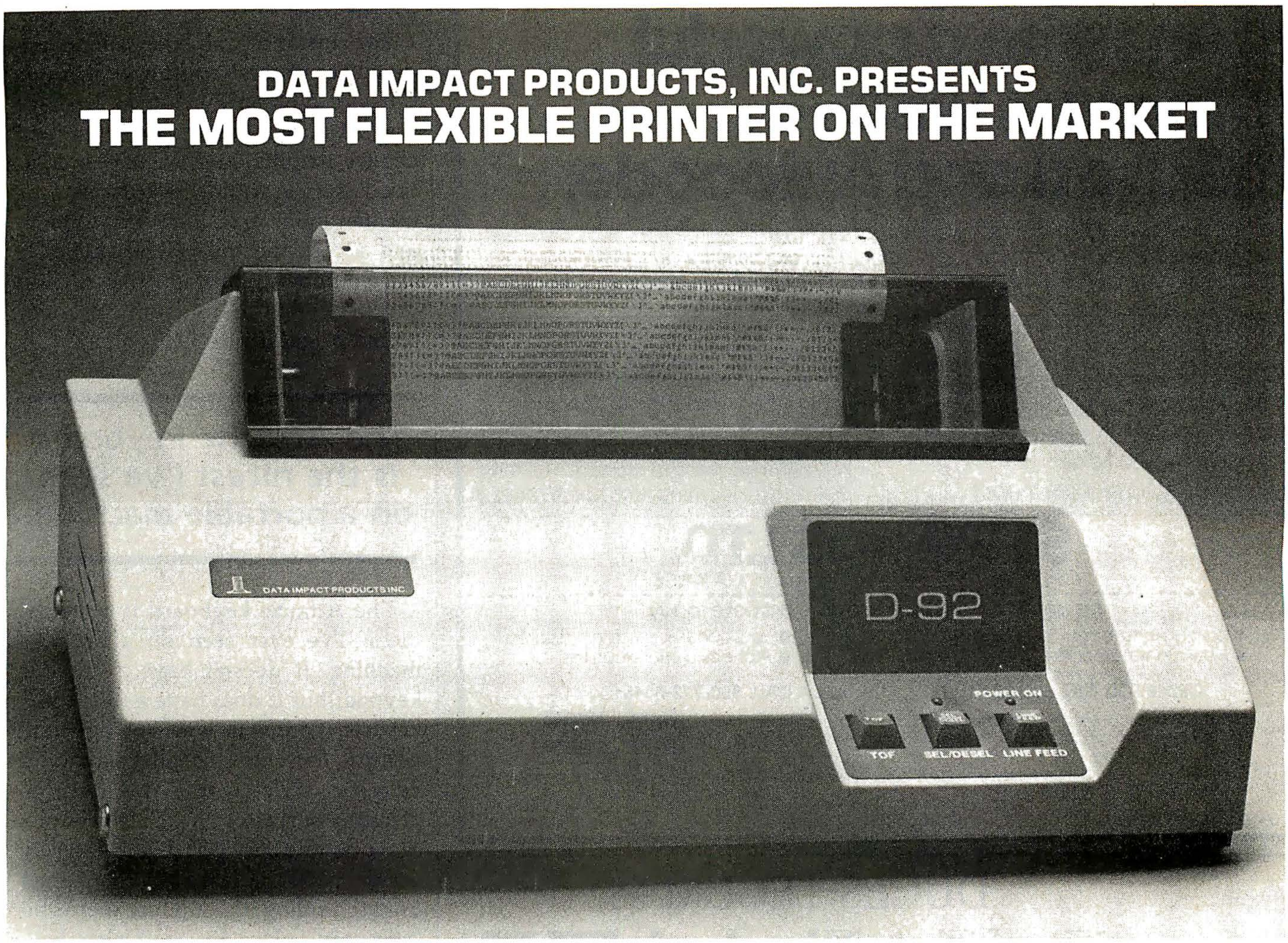
There's one annoying "feature": a key-click circuit that has an unfortunate sound. In fact, at first I thought it was some kind of squeak and squirted in a bit of WD-40 to try to still the noise. The "squeaky click" isn't all that loud, and after an hour you get used to it, but it would be awfully nice if they had a potentiometer on the thing to let you adjust the pitch or volume. The Otrona has complete software control over both pitch and volume. The Kaypro people tell me there's a program you can run to turn the key click off.

The Kaypro also has a large screen, certainly the largest screen you'll ever get in a portable machine. I measure the glass areas at 7 inches across and nearly 9 inches diagonal. It's green with a brightness control and has the usual 24 lines of 80 characters. I wish it had a knob for contrast as well as one for brightness, but that's only a mild preference.

The Kaypro will display the entire ASCII character set. It has true descender lowercase letters (that is, those with tails do go below the line). Even so, I'm not really fond of the characters. The lowercase "o" is or appears to me to be too large, and some of the other characters seem odd in size. Still, the display is readable, as you'd expect a larger screen to be. People with bifocals may have problems; that is, it's big enough for you to sit far enough away to look at it through the tops of your glasses, but for some reason the letters look better formed and just plain prettier if you get up closer and look through the bottoms. Do recall, though, that I have unusual eye problems, and my normal system has 16 lines of 64 characters displayed on a 16-inch screen.

Lovely Adelle

If my initial evaluation of Kaypro is "Good stuff!," my initial reaction to the Otrona Attache is "Great!" Of course, the Otrona costs about twice



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what the Kaypro does; but you get a lot for that.

For instance, all the minor annoyances of the Kaypro vanish in the Otrona. Not only can you suppress the Attache's key click, you can change its pitch and volume; and all this is simple to do. Just go Control-Escape and you're in a Setup mode; and across the top of the keyboard are a number of prompts that tell you precisely what to do, from control of screen brightness to bell volume.

The Attache keyboard is the nicest I've seen on a portable machine.

The Attache keyboard is quite the nicest I've ever seen on a portable machine. It doesn't have a numeric keypad; but it does have a full ASCII key set, complete with squiggle and vertical bar, etc. The key layout is Selectric style, with one not-too-pleasant surprise: the Delete key is down left. You won't hit it often by accident, but it takes a while to get used to finding it. I suppose there's no "standard" place for the Delete key, but I can't imagine why they put it *there*.

Alas, unlike the Osborne, the Attache has no place to stow the power cord or a box of disks (I don't think you'd want to carry disks in the drives). I've suggested to Otrona's management that they make a small Leatherette packet that will hold both power cable and disks and attach to the Attache's handle; but it won't be hard to make one if they don't do it.

Another minor deficiency is that there's no indicator light on the Caps Lock key, nor does that key stay depressed when pushed. Otherwise, though, it's an excellent keyboard and layout. The Shift and Return keys are oversize (although not greatly so). The keys are all placed pretty close together, and they utterly fill the lightweight little keyboard, so that the Otrona's keyboard *looks* small. By both measurement and feel, however, it is a full-size keyboard, every bit as big as the one on a



Televideo 950, or for that matter on an IBM Selectric (which it resembles). I know, because when I first saw the Otrona at a Los Angeles computer show, Greg Decoteau of Otrona and I actually carried the Otrona Attache keyboard to an exhibit that had a Selectric and laid the keyboard up against the IBM's. I have had no problems typing text into the Otrona.

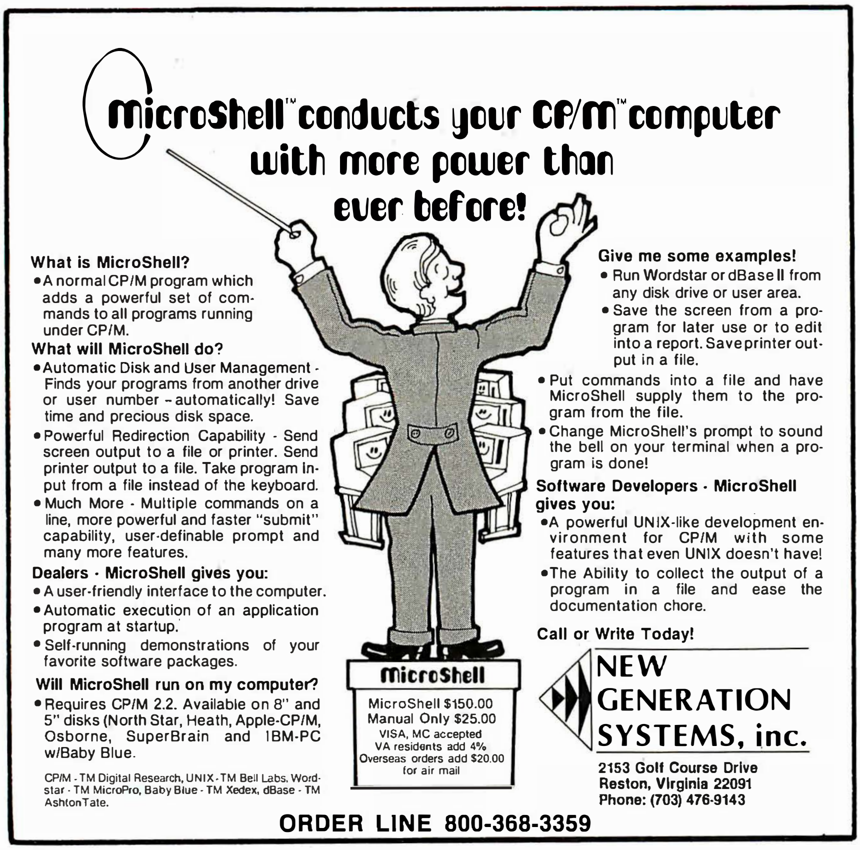
The Attache has even tamed Wordstar. There isn't room on the little keyboard for any special word-processing keys, but Otrona has done something as good and perhaps better: it has made the numeric keys across the top generate Wordstar commands. As an example, 6 is normal, and Shift 6 is the ampersand, but Control 6 toggles you into Insert mode, and Shift Control 6 starts a Block in the text. Each key has both Control and Shift Control special meanings for Wordstar, and attractive little labels at the top make it easy to figure out what the various keys turn into.

"Special-feature" keys get you to top of screen, change help levels, find/replace, margin release, reformat, and so forth. They make Wordstar a lot easier to use, or at least I found it so; I was able to write in hotel rooms in Rome, at cafes in Venice, and in other unusual places.

There's been a lot of thought given to the Otrona. Some of it doesn't show until you need it. For example, the Reset key is on the keyboard, something I would have paid to avoid; but it has been tamed. The key is on the left side, outboard of the Shift key, and to use it to reset, you must press Reset while holding down the right-hand Shift key. Ingenious.

It has lots of other nice touches. The Otrona Attache's large handle swings underneath and locks in place to put the display at a convenient uptilted angle. The disk doors open and close with a positive feel. The green screen is small—4 inches wide by 3¼ inches high—but it is bright and very readable, with well-formed characters. I found that with the Otrona on the table in front of me and the keyboard in the natural position, I had no trouble at all reading the 24 lines of 80 characters.

Continued on page 438



The Otrona uses double-sided double-density small disks, so that you have 360K bytes per disk; more than I have ever had on Ezekial. You can put fair-size documents on them. I still retain some prejudice against small disks, but I have to admit that the Attache may overcome my doubts, since it has worked under horrible conditions without a glitch.

The Attache comes with CP/M, Microsoft BASIC, and Wordstar. It also includes an unusual program called Valet. The Attache always knows what time it is, because it keeps both time and date stored in nonvolatile memory. With the Valet program, you can turn the Attache into an alarm clock with up to four alarms that both sound audibly and flash messages on the screen. Valet in the alarm mode interrupts your current job, but does it nondestructively. The Valet program also has a four-function calculator built in.

Communications gear lets you transfer files to and from 8-inch disks, and the Attache can become a very sophisticated terminal to drive either a modem or another computer. The Attache is supposed to do that painlessly, and I have no reason to doubt it since the little dear has done everything else I asked her to. I haven't actually used her as a terminal or extracted my files into The Golem because I foolishly managed to blow something internal in Rome.

As a sophisticated terminal, the Attache can drive a modem or another computer.

That was particularly stupid of me. The Otrona comes with a simple mechanism that lets you change from 110 to 140 on up to 250-volt (V) input voltage, and it apparently isn't interested in the *frequency* of that juice either. However, some of the older Roman hotels have nonstandard 225-V outlets. I had no way to plug the Otrona in—so I foolishly converted it back to 110 and tried to run it with the converter for my wife's hair dryer. It did run, too, for a minute or so; then with a gentle pop, it expired. Otrona figures it will be fixed in no time, though; its dealers simply replace modules until everything works, then send the modules back to the factory for rebuilding. Since mine didn't come from a dealer, it's taking them a day to figure out which one is going to do my servicing; otherwise, I'd have her fixed already.

Anyway, since the Attache has simple ways for getting stuff to and from your 8-inch disks, there's little I run on Zeke that won't soon be available on the Otrona, meaning that I can carry a full desktop computer anywhere, use it, and bring the results home for processing on my big machines. Of course, "big" here is a relative term, since the Otrona is

"bigger" in terms of memory and computing power than Zeke was when I first got all 70 pounds of him. Adelle (I think that's her name; we'll see when they get the power supply fixed) is only 18 pounds and looks gorgeous on a Venice cafe table.

Lots of New Machines . . .

It's really too early for a final evaluation of these machines; I haven't used them long enough. My first impression is that the Osborne remains the VW of the microcomputer field; it's cheap, reliable, handles standard programs well, and, while inconvenient, has some plain-wrapper features to compensate. The software with the Osborne retails for about as much as the whole Osborne package complete with computer.

Of course, I've had the Osborne longer than the others, so I'm very familiar with both its strengths and weaknesses. One real strength is Osborne service, which remains efficient and fair-dealing. That's been not only my experience, but that of all but one of those who have written me about it.

The Kaypro is more like a Chevrolet as the Chevy used to be, reliable and rugged, without much trim or visible frills. The software package with the Kaypro is not as extensive as the one you get with the Osborne. The screen is larger and displays all 80 characters of a line. The keyboard is more complete, and the disks hold more. (Osborne now has a double-density option and 80-character screen.) Also, since the Kaypro comes with a *compiling* BASIC, it won't be as immediately useful to beginners who want to write their own programs. However, you can buy Microsoft interpretive BASIC for the Kaypro.

Select, the Kaypro word processor, is unlikely to be as complete and full of frills as Wordstar. Since I'm not really fond of either Select or Wordstar, I'm the wrong one to judge between them. I did find Select remarkably easy to just sit down and use, and I'm certain that Kaypro with Select is more than adequate as a word processor. Provided that you like the feel of the keyboard and are comfortable with the display, I'd have no hesitation in recommending the Kaypro as a good first machine for a beginning writer, and indeed I may recommend it to one of my partners as his first machine.

The Otrona is definitely the BMW of the portable machines. It comes with an adequate if not extensive software package, it is the smallest and lightest of the portables, and it is by all odds the most gorgeous. The disks run quietly and I had no hitches with them, even after transporting Adelle a long way across water; and that 360K bytes per disk is *very* nice.

I loved the keyboard, and the screen display was plenty good enough. Since the Otrona Attache comes with a video output already built in, you can set it up with a large video monitor if you like. It is certainly more than adequate as one's only machine. Of course, for its price, there are other machines that use a bus and are therefore more easily expanded.

(To continue the analogy, my Compupro is more like an International Scout. Of course, my personal car *is* a Scout. . . .)

The Bottom Line

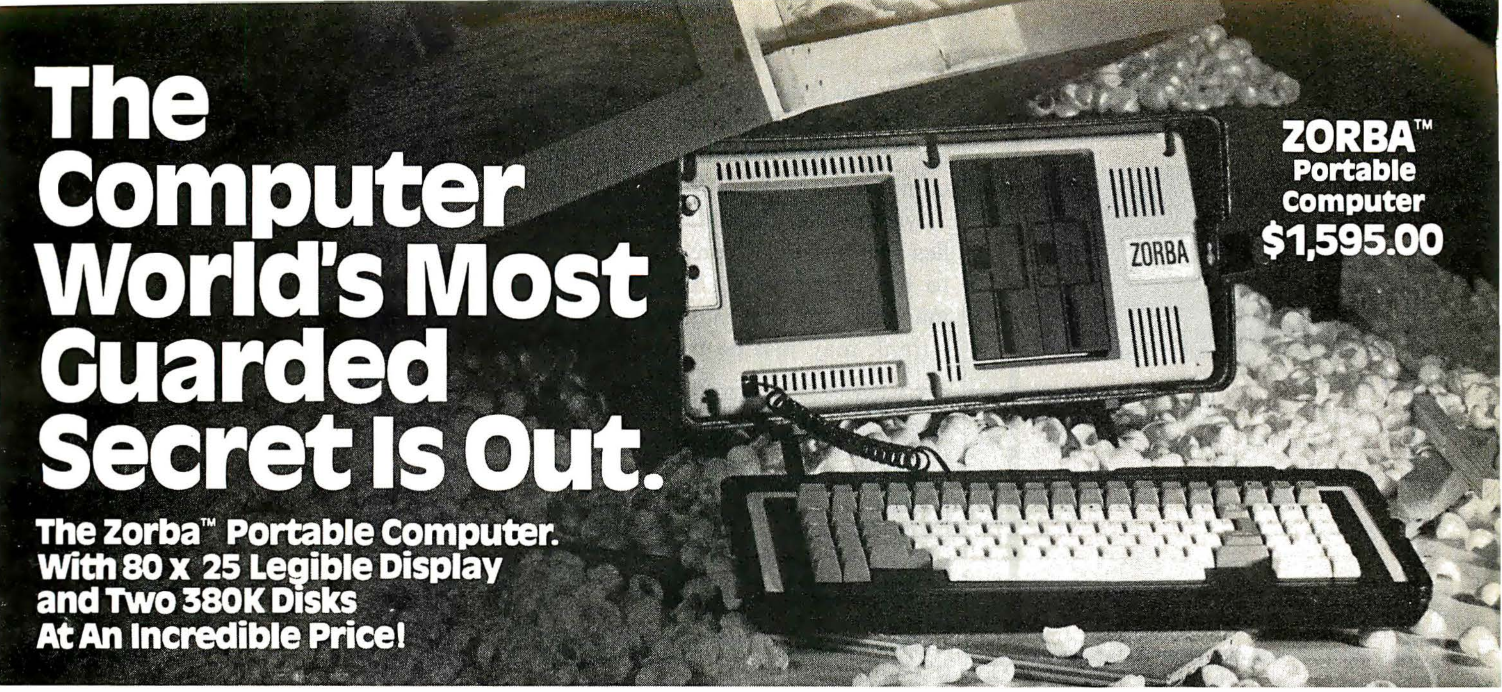
The Osborne, as it stands, is just a bit limited in file storage to be your only computer, although now that Osborne has the double-density package, things will change quite a lot.

The Kaypro would certainly work as an "only," although I have reservations about the SBASIC that comes with it.

The Otrona is beautiful, and I've used it enough to know that I could certainly live with it as my only machine; and it's *really* portable, a true desktop computer that you can carry around.

And Still More Next Month

While in Chicago I saw the prototype of Lobo's new $800 machine. One of those is supposed to be on its way here. Meanwhile, we have an Apple II up and running, and we're



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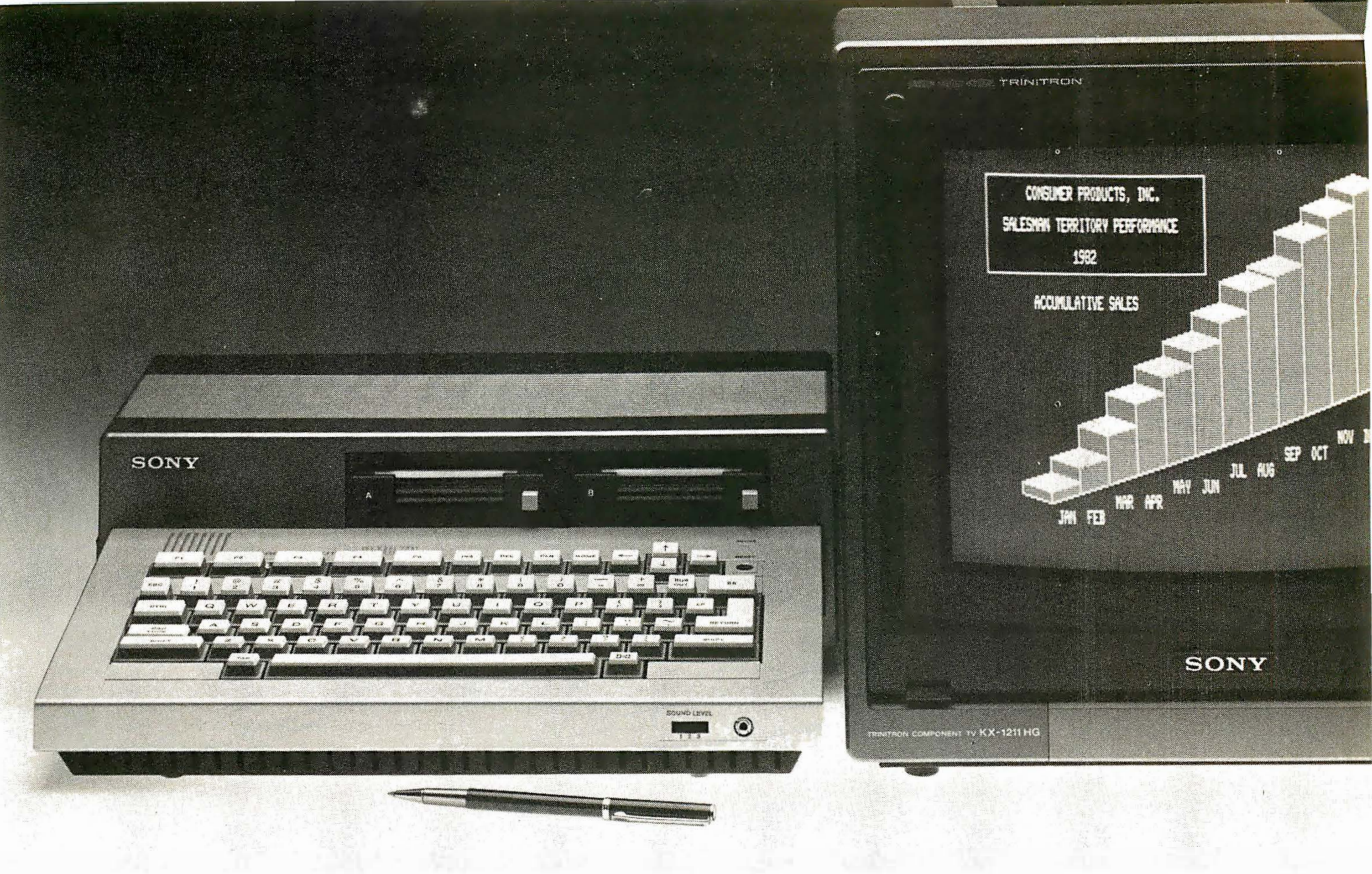
getting an Atari 800. (I'm going to do a book on small computers. I am also up to my clavicle in small computers.)

Meanwhile, Ezekial, my first love, lies unconscious. Tony says he'll get to him after we set up yet *another* machine, one that makes use of what I think may just be the world's best keyboard and will deliver its output to my 16-inch screen. It's another Compupro.

All this means that next month I'll be able to continue my comparisons of small machines. There's also a large stack of software for review. The microcomputer revolution goes on. I love it. ■

Items Reviewed

Attache Computer Otrona Corporation 4755 Walnut St. Boulder, CO 80301 (303) 444-8100		$3995
Janus/Ada Compiler RR Software POB 1512 Madison, WI 53701 (608) 244-6436	CP/M other systems	$300 $400
JRT Pascal JRT Systems 1891 23rd Ave. San Francisco, CA 94122 (415) 566-5100		$29.95
Kaypro II Computer Non-Linear Systems Inc. 533 Stevens Ave. Solana Beach, CA 92075 (714) 755-1134		$1795
MITE Mycroft Labs POB 6045 Tallahassee, FL 32301 (904) 385-2708		$150
Osborne 1 Osborne Computer Corporation 26500 Corporate Ave. Hayward, CA 94545 (800) 772-3545, ext. 905 (California) (800) 227-1617, ext. 905 (outside California)		$1795
Plannercalc Comshare Target Software Suite 200 1935 Cliff Valley Way Atlanta, GA 30329 (404) 634-9535		$99
Software Toolworks 14478 Glorietta Dr. Sherman Oaks, CA 91423 (213) 986-4885		Write for free catalog
Unica **Unica/XM-80** Knowlogy POB 283 Wilsonville, OR 97070 (503) 639-3420		$95 $195



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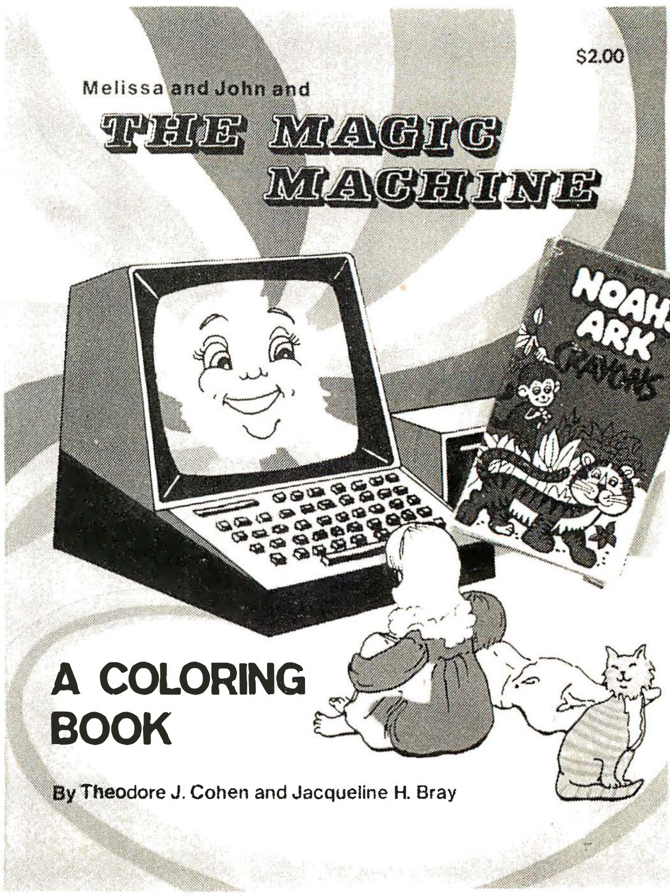
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A Colorful Introduction to Computers

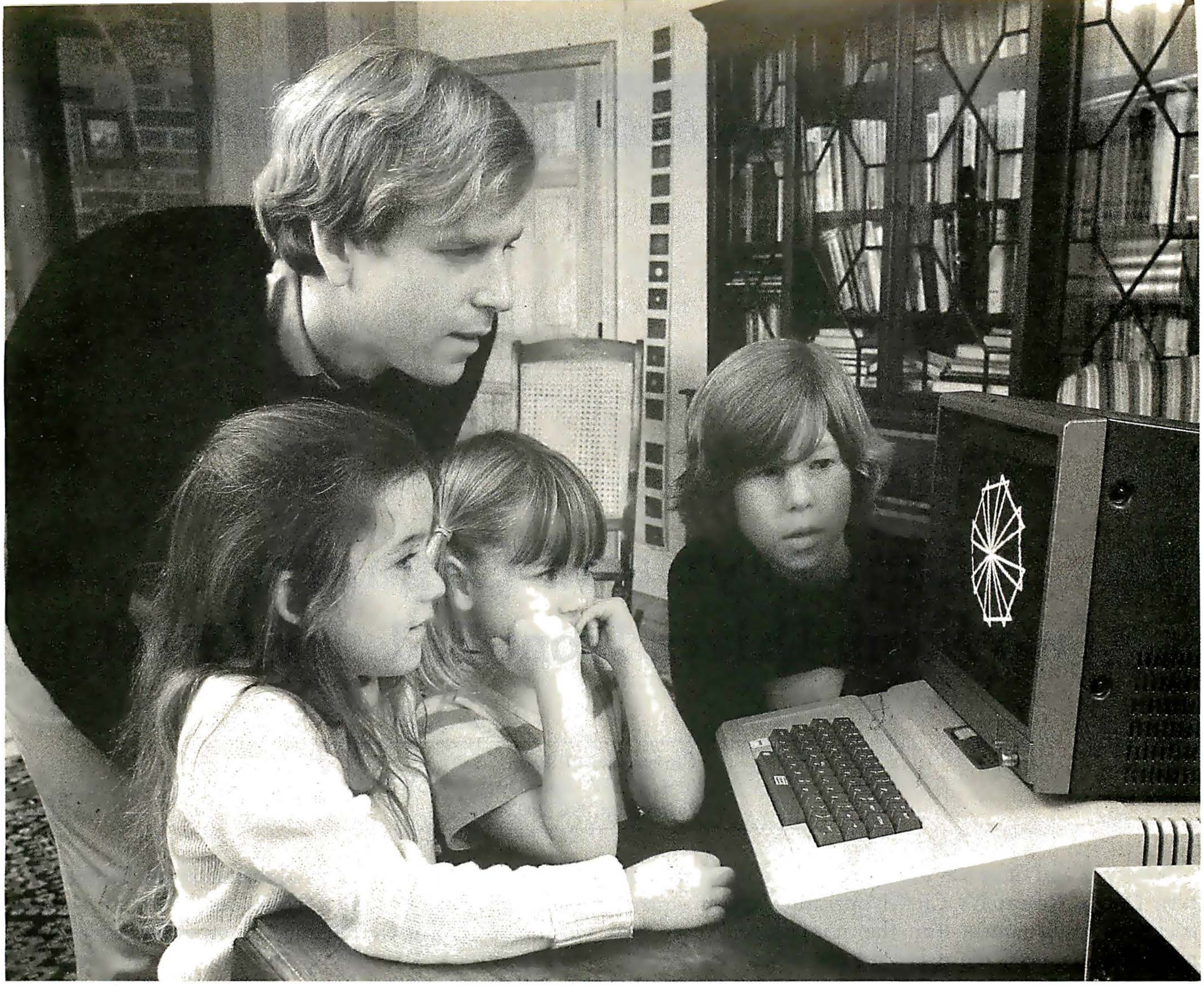
Here's a fun and educational coloring book to introduce your home computer to the youngest members of your family. *The Magic Machine* explores the excitement and wonder of computers from a young child's point of view. Theodore Cohen's story, written for beginning readers, answers many of the basic questions children ask about the magic machines that are coming into our homes in ever-growing numbers, and Jacqueline Bray's line drawings capture the vivid and often funny images that arise from the inquisitive minds of children as they seek to understand the world around them. Packaged complete with its own set of crayons, *The Magic Machine* will help children appreciate computers even before they are old enough to begin using them.



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Supervyz and Organizr
Two Menu-Driven Front Ends for CP/M

Christopher O. Kern
201 I St. SW, Apt. 839
Washington, DC 20024

Supervyz and Organizr are two software products that turn Digital Research's CP/M operating system into a friendlier environment for the nontechnical user by mediating between the user and the operating system. The user sees a menu of available operations and simply chooses the one desired. The operating system receives a syntactically correct command that is generated automatically in response to the user's selection. (Supervyz and Organizr have a great deal in common, and unless otherwise specified, my comments apply to both.)

CP/M may be the most widely used disk operating system in the world of microcomputers, but obviously not everyone finds it congenial. That's why there is a substantial market for books explaining CP/M, and why many hardware manufacturers and software vendors feel they have to supplement the documentation provided by Digital Research.

For the "naive" user, especially the one who considers the computer an appliance rather than a hobby, learning CP/M can present a formidable challenge. I recently saw this first-hand when I set up a small computer system for a friend to use in his political-consulting business. Because of the wide variety of CP/M-compatible software, I didn't seriously consider any other operating system. It never occurred to me that my friend would find it difficult to learn how to use the basic system commands he needed, such as those for copying a file, changing its directory attributes (e.g., making it read-only), displaying the contents of a disk, or invoking an application program with the proper command-line syntax. He did have trouble, though, and each foray into his software manuals seemed to confuse him even more. Ultimately, I had to provide him with a "cookbook" containing precise instructions for each function and program he was likely to use.

What CP/M Demands

To use CP/M (or any other general-purpose operating system), you need to have a reasonably clear idea of how the host computer system is organized. At the very least, you need to know when a new program must be executed to perform a given function, what options are available for each program or system command you intend to use, and the particular command syntax that is required to start each program. The two menu-driven front ends reviewed here make it possible to use CP/M without understanding precisely what is going on. All you have to know is what you want the machine to do.

For example, to copy a file under CP/M, you have to understand that copying files is performed by the Peripheral Interchange Program (PIP) and that PIP can be executed only from the command level of the operating system and not from within another program. You must also know which options are appropriate (or required) for copying the particular file and that the command syntax for copying files with PIP is:

PIP *drive:newfile.typ=drive:oldfile.typ[options]*

where *drive* designates the disk drive on which a file resides, *oldfile* and *newfile* are file names, *typ* is a file type or extension, and *options* is a series of single-letter

At a Glance

Name
Supervyz

Version
1.34

Type
Menu-driven front end for the CP/M operating system

Distributor
Epic Computer Products Inc.
18381 Bandolier Circle
Fountain Valley, CA 92708
(714) 964-7722

Price
$150

Computer
8080-based machines running CP/M 1.4 or MP/M 1.1 or later

Documentation
77-page manual

Audience
CP/M users wanting a simplified command interface to the system; dealers, consultants, and other system integrators

At a Glance

Name
Organizr

Version
2.2.2

Type
Menu-driven front end for the CP/M operating system

Distributor
The Information People
443 Hudson Ave.
Newark, OH 43055
(614) 349-8644

Price
$195 ($25 for manual only)

Computer
8080-based machines running CP/M; requires 48K bytes of RAM (random-access memory)

Documentation
31-page user and reference manual

Audience
CP/M users who want a simplified command interface to the system; dealers, consultants, and other system integrators

or letter-plus-integer optional parameters that are to be passed to PIP.

If you fail to use the correct command syntax, you're likely to be rewarded with a terse error message that serves as little more than a visible indication that something is wrong. The response that you receive may be even more confusing if you try to run the copying command from within an application program—e.g., in response to a prompt from a word-processing or accounting program—not realizing that a prompt from an applications program is different than a prompt from CP/M.

Menus

Supervyz and Organizr simply present you with a menu that includes the item "copy a file." They *ask* you for the appropriate disk drives and file names to use. If you need help understanding the entries on the menu, they supply explanations in response to a question mark entered from the keyboard, instead of forcing you to search through the system or application-program manuals. (See listing 1.)

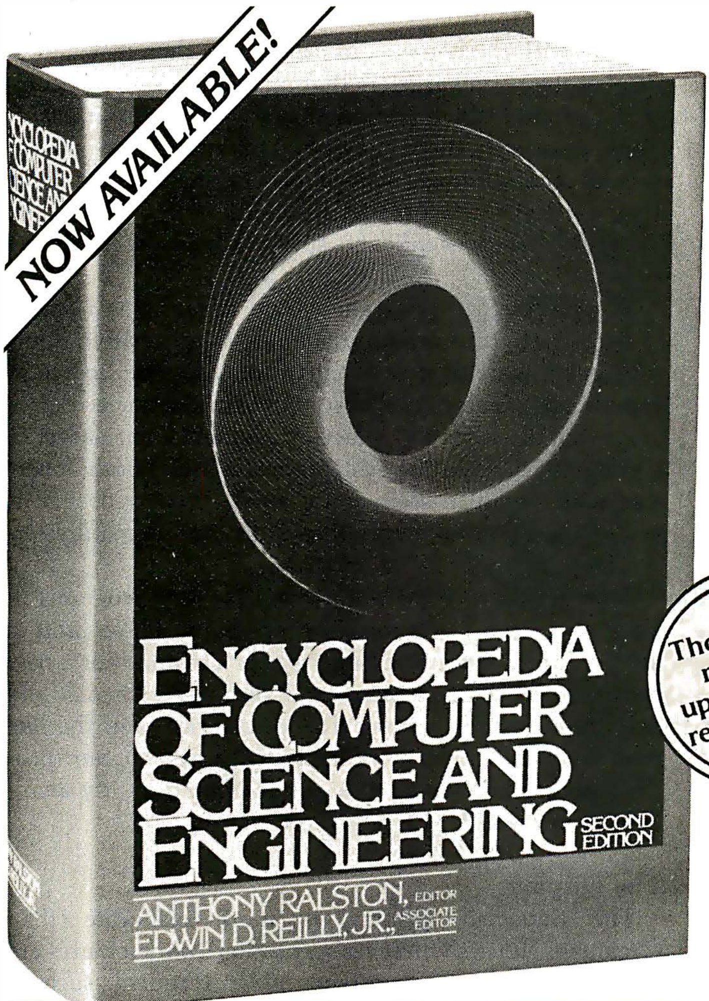
They also divide up the resources available on a particular computer system into groups, each of which is composed of as many as 10 programs or functions with Supervyz and up to 12 with Organizr. Each group is presented as a separate menu of related programs, and each menu corresponds to one of the major applications of the computer system. On a business system, for example, one menu might provide word processing, another inventory management, a third might be for payroll, and a fourth for accounting.

Grouping related functions together on a menu in this fashion is an important organizational convenience. It means that you are provided with an explicit reminder of what options are available on the computer system to perform a given task. Commonly used programs or system commands, such as those to copy files or list directories, can appear on more than one menu. This reduces the need to flip from one menu to another in the course of a session at the computer.

Menus of Menus

Both Supervyz and Organizr arrange menus into a hierarchy. Any entry on a given menu can invoke a submenu with 10 or 12 programs (or even sub-sub-menus) of its own. In the example used earlier, one of the choices on the main menu would be "inventory management." Choosing inventory management might lead to a menu with choices for updating the inventory, reporting on turnover, ordering or recording the receipt of new supplies, etc. The updating and reporting choices might represent individual application programs. But the "new supplies" option might lead to a new menu with options for writing a purchase order, matching an invoice against a previous order, showing how many orders are outstanding from a particular supplier, and the like. It might also contain a reference to the program for updating the inventory. This would be the same program that was accessible from the main inventory-management menu, but used in a different context: to remind the employee using the new-supplies menu to update the inventory when the new supplies are received.

Reorganizing a computer system's resources into a hierarchical structure helps clarify the relationship among the programs available. This approach is reminiscent of the directory structure of Bell Laboratories' Unix



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operating system, though the Unix system's generality is lacking. Still, as the disk capacity of small computers increases, a logical arrangement of the programs that are available is a significant benefit. It helps you cope with complexity. You never have to choose among more than a dozen functions. Minimizing the number of options confronting you makes each decision easier.

Speed and Stability

As you might expect, these programs exact a price for the convenience they provide. Extra disk accesses are necessary to display new menus or to execute CP/M commands. It also takes more time to update the console display with the contents of each menu than it would to display the two characters that make up the CP/M command prompt. On a computer that uses floppy disks for mass storage, delays between commands are usually several seconds longer with Supervyz and Organizr than they are with unadorned CP/M. (By the way, neither program has a signficant speed advantage over the other.)

A well-designed program should never bring about a system crash, and program stability is especially important in software that is designed for inexperienced computer users. Stability is absolutely crucial for any program that attempts to replace or augment some aspect of a computer's operating system. Fortunately, both Supervyz and Organizr seem quite solid. Error recovery is smooth, even from errors that cause the premature termination of applications programs.

Both products come with several utility programs in addition to the menu-selection program. These utilities are used for configuring Supervyz or Organizr for a new computer system, creating and displaying menus and help messages, displaying disk directories, and the like (the expanded Supervyz directory-listing program produces a display similar to a public-domain utility available from the CP/M User's Group).

Listing 1: *Sample screen displays of the two CP/M front ends. Supervyz (listing 1a) is supplied with a menu of file- and disk-support functions. Once an entry's number has been selected, the appropriate prompts for that function appear. The bottom of the screen is reserved for a catalog of the files relevant to the function selected. Organizr (listing 1b) provides space for short comments about each entry and gives instructions about the possible commands for the entry selected.*

(1a) Supervyz

```
                      File and Disk Support Functions
 1) Format a Program Disk                 6) Copy a Systems Area only
 2) Format a User Disk                    7) Disk Recovery and Repair
 3) Select Default Disk and User          8) Write-Protect File(s)
 4) Copy a file                           9) Write-Enable File(s)
 5) Copy an entire disk                  10) Extended Volume Table of Content
                  (Function 0 returns to next higher menu)

 Please enter the number of the desired function (0 if none, ? for help) [4 ]
       Name.type of file to be copied? [              ]
       Drive you are copying from?     [ ]
       User Area you are copying from? [0 ]
       Drive you are copying to?       [ ]
       New file name.type? (if changed)[              ]


 Default Drive = A     Volume Table of Contents  (VTOC)     Default User =  0
::DIAGNOSE HLP A  0      ::DIAGNOSE MNU A  0      ::DIR22    COM A  0        ::
::DISKSUPT HLP A  0      ::DISKSUPT MNU A  0      ::DUMP22   COM A  0        ::
::ED       COM A  0      ::FORMAT   COM A  0      ::FORMFEED COM A  0        ::
::HELP     COM A  0      ::HELP     HLP A  0      ::INSTALLZ COM A  0        ::
::LIST66   COM A  0      ::MENUSDEF COM A  0      ::PIP      COM A  0        ::
::READ     ME  A  0      ::READ24   COM A  0      ::Push DOWN-ARROW for more!::
```

(1b) Organizr

```
==============================================================================
V3.1a                 Office System 80 Function Selection
==============================================================================

      < 1> - Accounting System          (AP, AR, GL, PR, Job Cost, Invoicing )
      < 2> - BASIC Interpreter          (Call MBASIC 5 interpreter cmd. mode )
      < 3> - Calculator, MicroPro       (CalcStar  Key ";H" for instructions )
      < 4> - Calculator, Sorcim         (SuperCalc spread-sheet calc. system )
      < 5> - CP/M Command               (Execute a CP/M command - use CAUTION)
      < 6> - Data Base System           (dBASE II relational DBM command mode)
      < 7> - File Management            (DataStar file entry and maintenance )
      < 8> - Form Entry Generator       (Create new entry forms for DataStar )
      < 9> - Mailing System             (MailSort edit, select/sort NAD file )
      <10> - Maintenance Menu           (Prepare New Disks,  Copy Files, etc.)
      <11> - Planning Language          (Target planning language w/spreadsht)
      <12> - Telecommunications         (LYNC- Use ©T ©A for menu. ©C to Link)
      <13> - Word Processing            (WordStar, MailMerge, SpellStar menus)
      <14> - Finished with this function

==============================================================================


Function #     Type
----------     ----

    1          Mount FINANCE.DSK on Drive A:
               Command: ORGANIZR
    2          Command: MBASIC
    3          Command: CS
    4          Command: SC
    5          Command: ((Type a CP/M command & press <ENTER>))
               Command: PAUSE- Function Complete
    6          Command: DBASE
    7          Command: DATASTAR
    8          Command: FORMGEN
    9          Menu:    MAILSORT
    10         Menu:    SYSUTIL
    11         Menu:    TARGET
    12         Command: LYNC
    13         Command: WS
               Command: ERA *.BAK
               Command: A:
```

The Displays

The Supervyz display is more elaborate than Organizr's. It uses whatever special hardware features are available on the host system's video terminal, such as reverse-video and half-intensity fields. When you choose an option that requires specific parameters, such as a distinct file name to use or which disk drive to search, the questions appear in a fill-in-the-blanks format below the option list. Additionally, Supervyz provides a window just below the parameter field in which a disk directory suddenly appears whenever you are asked to supply a pre-existing file name (see listing 1a). These features make Supervyz very interactive, which gives the impression of speeding everything up.

By contrast, the Organizr display is relatively austere (see listing 1b). The sole special terminal-hardware feature that it supports is to clear the video screen. Only the menu itself is displayed on the terminal. Unfortunately, after you choose an option from a menu, Organizr has a tendency to show on the screen the CP/M command that it generated. Most users would no doubt get used to that quirk, though it might be a bit confusing at first.

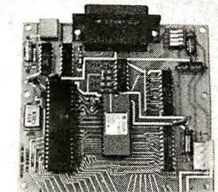
Installation

Both packages come preconfigured to use their intrinsic utilities along with the built-in commands and system programs common to CP/M, but custom installation is required to make use of the specialized application software that is available on a given computer system. This will normally be done by the dealer or consultant who installs the system for the end user; however, both Supervyz and Organizr provide instructions for end users who

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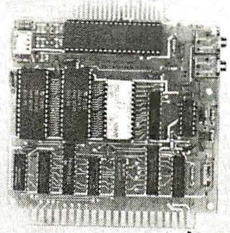
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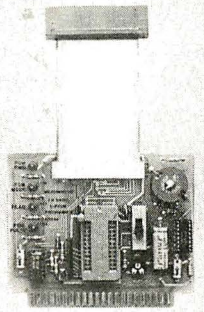
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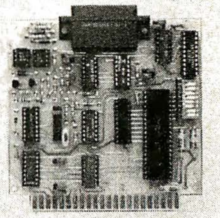
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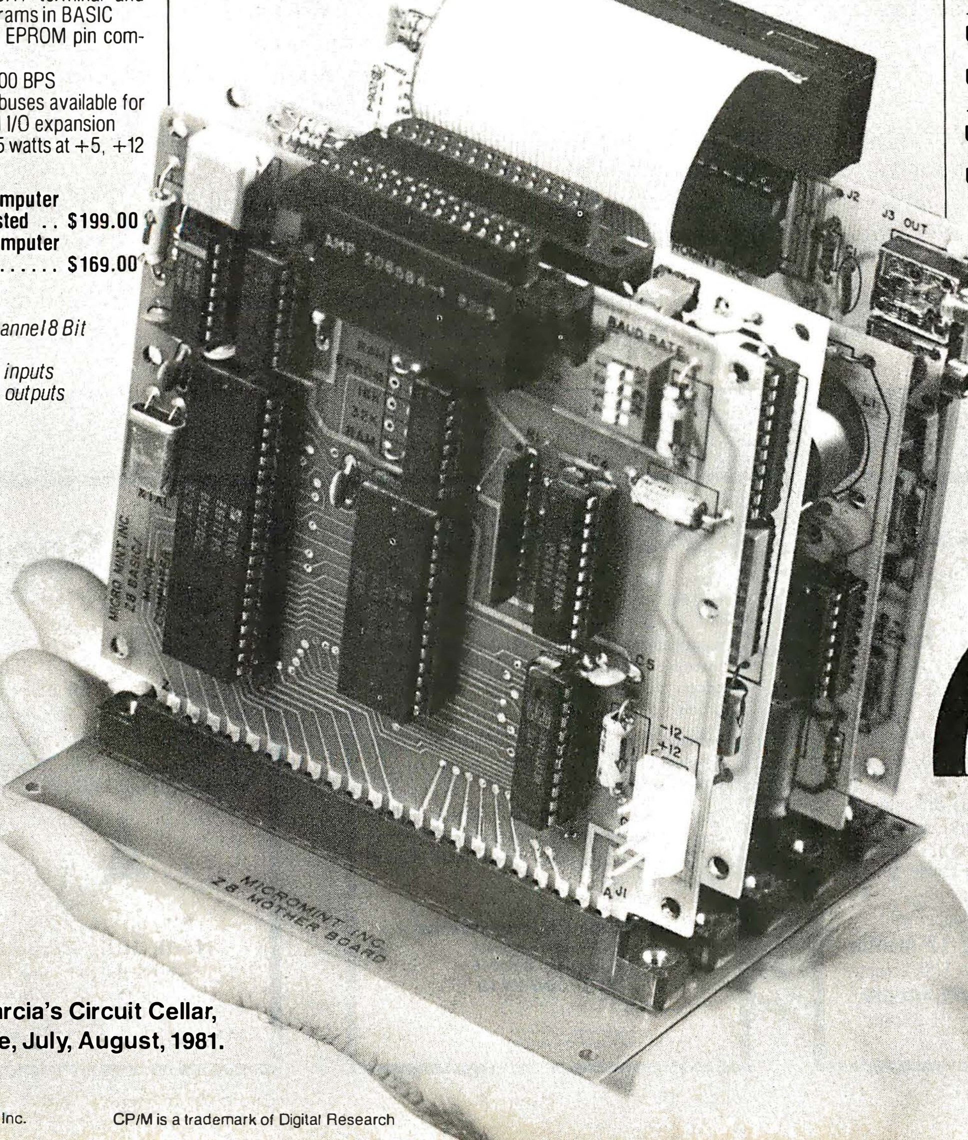
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want to change their system's configuration or install the products. Supervyz has the more complex installation procedure (partly because it is the more flexible system), but, because it is well automated, it is quite painless.

As I mentioned earlier, these programs function as front ends to CP/M. They translate the menu selections made by the operator into standard CP/M commands. They do not replace the operating system. The CP/M command interpreter is still doing the real work, although its operation is mostly invisible to the user. Supervyz occupies about 4K bytes of memory at the top of the host system's free address space. Organizr does not tie up any memory, although the manual says a 48K-byte system is required. Both programs can be loaded under CP/M or set to start automatically whenever the computer is turned on.

The amount of disk storage that is necessary to use these products will vary with the number and size of the menus (and, with Supervyz, the number of help files that are needed on a particular system). As distributed, the Supervyz package takes up 149K bytes of disk space. Organizr's distribution package takes up 31K bytes. Most of this distribution software must be kept on-line, and both products require that certain CP/M utilities be present on disk. As a rough estimate, I think the *practical* use of either product would require approximately the storage capacity of a single-density 8-inch disk (i.e., 256K bytes).

Configuration

Both packages include configuration programs that can customize the products for various video terminals. The Supervyz configuration process is more elaborate because it uses more of the features of the available terminal. I tested it on a Heath H-19 and a Televideo 950. Shading, reverse video, and the use of multiple display intensities (on the Televideo) made for impressive and attractive menu displays.

Most versions of CP/M allow Supervyz or Organizr to be loaded automatically whenever the computer is turned on. The Supervyz configuration program will do this for some systems. In most cases, however, the installer will have to determine the disk track and sector where the CP/M command interpreter resides if auto-start is necessary. In a few implementations of CP/M, such as the one for my Heath H-8, none of that is necessary because an auto-start feature is provided as part of the CP/M BIOS (basic input/output system).

These are well designed products, and it is a pity that their documentation does not come up to the high quality of the software. Both user's manuals are badly written and somewhat disorganized. Neither has an index. Despite their failings, both manuals will probably be adequate for the average end user, because in most cases the system will be configured by a professional and, once it is installed, it should rarely be necessary for the end user to refer to the written documentation. A computer system that is designed around these software packages will pretty much explain itself.

Conclusions

Supervyz and Organizr provide a simple, menu-driven environment for the CP/M operating system. They make CP/M accessible to inexperienced computer users; no knowledge of CP/M command syntax is necessary.

Both Supervyz's and Organizr's menus group computer-software resources into a hierarchy of functions. On computer systems that are used for multiple applications, this helps the user decide how to perform a given task.

These programs are well designed and stable, but both require extra disk accesses that slow down CP/M somewhat.

Supervyz and Organizr can be installed by either a systems integrator or an end user, although installation requires some knowledge of CP/M.■

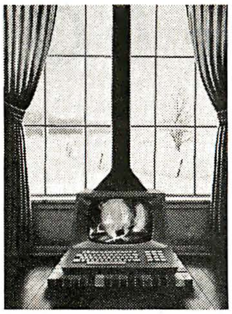
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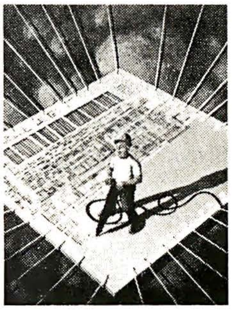
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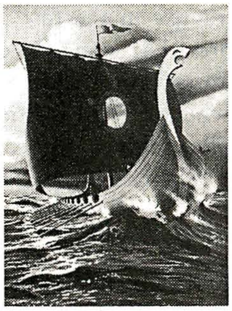
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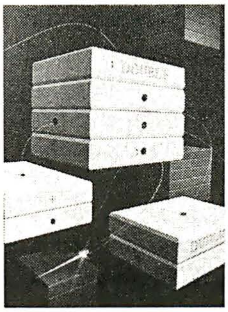
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As avid fans and teachers of Pascal, we tell people to change standard Pascal commands if they don't like them. One way to do that is to create commands through user-defined procedures which can then be placed in a library. Using this technique, we developed procedures that solve a text file input/output (I/O) speed problem in Apple Pascal.

Background

In the course of our work with Apple Pascal over the last two years, we began using the Pascal Editor for some of our word-processing needs. We wrote a text-printing program to format text files with pagination, headings, underscoring, and so on. Eventually, what started as a very simple tool acquired some rather sophisticated features. Still, the program ran slowly. We assumed our programming technique was responsible for the problem. At the same time, we were aware of speed problems in the Apple implementation of the READLN command on text files.

In an attempt to explore the problem, we wrote a small test program to examine the speed of the standard Apple Pascal text file I/O commands READLN and WRITELN. After experimenting with the program, it became obvious that the speed of our printing program was heavily influenced by READLN and WRITELN. As a result, Brook Richan wrote a sequence of procedures (see listing 1) to replicate the function of the RESET, REWRITE, READLN, WRITELN, and CLOSE commands on text files. A test program using these new procedures ran an astounding *8¼ times faster* than the program that used the standard commands.

Technique

To implement our procedures, we chose to functionally replicate the standard Pascal I/O commands (see table 1). We also made the calling parameters compatible with the standard Pascal commands. We used the following features in the fast I/O procedures:

A. **File Variables:** When a file is declared in the VAR section of a Pascal program, space is allocated (on the stack) for control information about the file. Because we wanted to override Pascal's method of reading text files, we declared our own file of type FILE. That enables Pascal to perform low-level, high-speed BLOCK I/O.

B. **TYPE Statements:** In order to functionally replicate standard Pascal I/O commands, it was necessary to define a special I/O buffer for use in the fast I/O procedures. We defined a record that consists of a file variable, a file buffer, a character count, an end-of-file status, and a mode status. Because Pascal will not allow the definition of a file variable within a record type, it was necessary to define the TYPE statement in the following manner:

```
TYPE BUFTYPE =      PACKED ARRAY [1..1025] of CHAR;
     FILETYPE =     RECORD
       FL:          ^FILEOFTEXT;
       BUF:         ^BUFTYPE
       CURPTR:      INTEGER;
       ENDOFFILE:   BOOLEAN;
       LASTMODE:    (WRITEMODE, READMODE);
     END;
```

In the above statement, BUFTYPE is the size of the page used by the Apple Editor +1.

There are some subtle maneuvers here. We circumvented the file-reference problem by defining a pointer to

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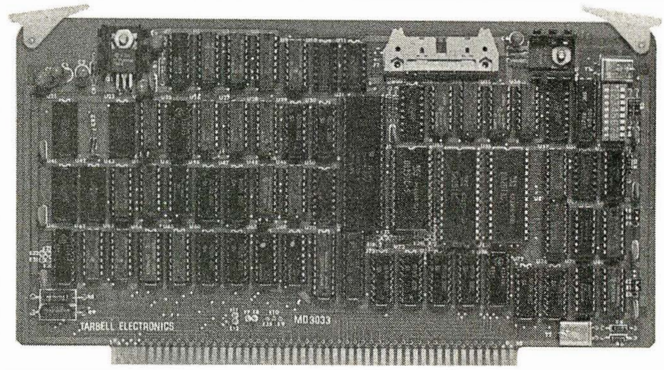
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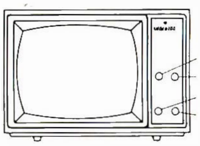
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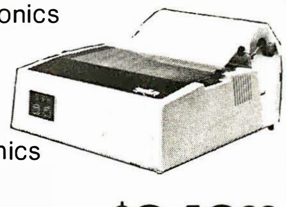
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Calling Parameters

RESET	(file variable, file name)
FASTRESET	(FILETYPE variable, file name)
REWRITE	(file variable, file name)
FASTREWRITE	(FILETYPE variable, file name)
READLN	(file variable, string)*
FASTREADLN	(FILETYPE variable, BIGSTRING variable)
WRITELN	(file variable, string)*
FASTWRITELN	(FILETYPE variable, BIGSTRING variable)
CLOSE	(file variable, command)
FASTCLOSE	(FILETYPE variable)**

*Only one of several variations of the verb. This happens to be one of the forms most commonly used with text files.
**We have chosen to use the CRUNCH option of the CLOSE if the last action was a write and a LOCK if the last action was a read.

Table 1: *A comparison of calling parameters. The standard version is on top; the high-speed equivalent is below.*

a file variable (FILEOFTEXT). However, PASCAL will also not allow a pointer to a file to be declared. To get around this restriction, we defined a pointer to a file that has not yet been declared. Therefore, this TYPE statement must follow the above FILETYPE declaration:

```
FILEOFTEXT = FILE;
```

Because reading and writing strings longer than 80 characters may be desired, the following type is defined:

```
BIGSTRING = STRING [255];
```

C. **Heap Allocation and Pointers:** The fast I/O procedures use heap allocation for a data buffer and file variable. Because both the data buffer and the file variable are on the heap, pointers are needed for access to the data in the variables. The variable BUF in the FILETYPE record is a pointer to the data buffer. The variable FL is a pointer to the file variable.

D. **Block I/O:** If you are willing to pay the price in slightly increased code complexity, you can increase I/O speed substantially by using block I/O (BLOCKREAD, BLOCKWRITE) for reading and writing files. That technique was an absolutely essential ingredient in the success of our fast I/O procedures.

E. **Variable Declaration:** An example of the variables needed to call READLN and WRITELN is as follows:

```
VAR F:  FILETYPE
    S:  BIGSTRING
```

These procedures should substantially increase the speed of your Apple Pascal programs. And, of course, they are compatible with UCSD Pascal. ■

Listing 1: *Fast input/output procedures include FASTRESET, FASTREWRITE, FASTREADLN, and FASTCLOSE. Two demonstrations included at the end of the listing show the speed of the FASTREADLN and FASTWRITELN procedures.*

```
PROGRAM FASTIODEMO;

TYPE

(***************************************************************)
(*                                                             *)
(*            T Y P E   S T A T E M E N T S                    *)
(*                                                             *)
(* TYPEs for FASTRESET, FASTREWRITE, FASTREADLN and FASTCLOSE *)
(*                                                             *)
(***************************************************************)

        BIGSTRING  = STRING[255];
        BUFTYPE    = PACKED ARRAY[1..1025] OF CHAR;
        FILETYPE   = RECORD
                FL:        FILEOFTEXT;
                BUF:       BUFTYPE;
                CURPTR:    INTEGER;
                ENDOFFILE: BOOLEAN;
                LASTMODE:  (WRITEMODE,READMODE);
             END;
        FILEOFTEXT = FILE;

VAR
        (*-----*)
        (* Variables used in the demo at end of program *)
        (*-----*)

        FASTFILE: FILETYPE;
        I:        INTEGER;
        S:        BIGSTRING;
        RF:       TEXT;
        FN:       STRING;
        STRINGI:  STRING;
        CH:       CHAR;
        OLDFILE:  TEXT;


(***************************************************************)
(*                                                             *)
(*                   P R O C E D U R E S                       *)
(*                                                             *)
(*           PROCEDUREs for fast I/O on TEXT files             *)
(*                                                             *)
(***************************************************************)


PROCEDURE FASTRESET(VAR F:FILETYPE; FILENAME:STRING);

(*-------------------*)
(*  Do a 'RESET' for a TEXT file (open existing file) *)
(*-------------------*)

VAR     I:INTEGER;

BEGIN
  WITH F DO
    BEGIN
      (* Allocate the FILE variable on the heap *)
      NEW(FL);

      (* Allocate the data buffer on the heap *)
      NEW(BUF);

      (* Initialize the FILE variable to binary zeroes *)
      FILLCHAR(FL,SIZEOF(FILEOFTEXT),CHR(0));

      (* Initialize the data buffer to binary zeroes *)
      FILLCHAR(BUF,SIZEOF(BUFTYPE),CHR(0));

      (* Turn off run-time I/O error checking *)
      (*$I-*)

      (* Try to open the file *)
      RESET(FL,FILENAME);

      (* Check for I/O error *)
      IF IORESULT<>0 THEN
        BEGIN
          (* Can not open the file, set the HEAP pointer back to
             what it was before entering this procedure: then exit *)
          RELEASE(FL);
          EXIT(FASTRESET);
        END;

      (* Read the first 2-block data page. Ignore the 1st 2-block header *)
      I:=BLOCKREAD(FL,BUF,2,2);

      (* Turn run-time I/O error checking back on *)
      (*$I+*)

      (* Set ENDOFFILE to TRUE if not able to read the blocks *)
      IF (I<>2) OR (IORESULT<>0) THEN
        ENDOFFILE:=TRUE
      ELSE
        ENDOFFILE:=FALSE;

      (* Initialize read flags and buffer pointer *)
      LASTMODE:=READMODE;
      BUF[1025]:=CHR(13);
      CURPTR:=1;
    END;
END;


PROCEDURE FASTREWRITE(VAR F:FILETYPE; FILENAME:STRING);

(*-------------------*)
(*  Do a 'REWRITE' for a TEXT file (open new file) *)
(*-------------------*)

VAR     I:INTEGER;
```

Listing 1 continued on page 458

Circle 162 on inquiry card.

Circle 228 on inquiry card.

Circle 174 on Inquiry card.

Listing 1 continued:

```
BEGIN
  WITH F DO
    BEGIN
      (* Allocate FILE variable on the heap and initialize it *)
      NEW(FL);
      FILLCHAR(FL,SIZEOF(FILEOFTEXT),CHR(0));

      (* Allocate data buffer and initialize it to binary zeroes *)
      NEW( BUF );
      FILLCHAR( BUF,SIZEOF( BUFTYPE ),CHR(0));

      (* Try to open the file *)
      (*$I-*)
      REWRITE(FL,FILENAME);

      (* Check for errors *)
      IF IORESULT<>0 THEN
        BEGIN
          (* Free the heap space if an error occured *)
          RELEASE(FL);
          EXIT(FASTREWRITE);
        END;

      (* Write out two-block header *)
      I:=BLOCKWRITE(FL,BUF,2);
      IF (I<>2) OR (IORESULT<>0) THEN
        BEGIN
          (* Set ENDOFFILE if cannot write blocks *)
          ENDOFFILE:=TRUE;
          EXIT(FASTREWRITE);
        END;

      (*$I+*)

      (* Initialize flags and counter *)
      ENDOFFILE:=FALSE;
      LASTMODE:=WRITEMODE;
      CURPTR:=1;
    END;
END;


PROCEDURE FASTREADLN(VAR F:FILETYPE; VAR S:BIGSTRING);

(*--------------------*)
(*  Do a 'READLN' on a TEXT file *)
(*--------------------*)
VAR     I,NBK: INTEGER;

BEGIN
  (* Initialize input string to null *)
  S:='';

  WITH F DO
    BEGIN
      (* Check for need to read the next data page *)
      IF (BUF[CURPTR]=CHR(0)) OR (CURPTR>1024) THEN
        BEGIN
          (* Read the next page *)
          (*$I-*)
          NBK:=BLOCKREAD(FL,BUF,2);
          (*$I+*)

          (* Set ENDOFFILE to TRUE if cannot read any more blocks *)
          IF (NBK<>2) OR (IORESULT<>0) THEN
            BEGIN
              ENDOFFILE:=TRUE;
              EXIT(FASTREADLN);
            END
          ELSE

            (* Set buffer character count to beginning of the new buffer *)
            CURPTR:=1;
        END;

      (* Expand the space compression *)
      IF BUF[CURPTR]=CHR(16) THEN
        BEGIN
          CURPTR:=CURPTR+1;

          (* Turn run-time range checking off *)
          (*$R-*)

          (* Fill first part of string with specified number of blanks *)
          FILLCHAR(S[1],ORD(BUF[CURPTR])-32,CHR(32));

          (* Set the string length *)
          S[0]:=CHR(ORD(BUF[CURPTR])-32);

          (* Turn range checking back on *)
          (*$R+*)
          CURPTR:=CURPTR+1;
        END;

      (* Scan for the next carriage return *)
      I:=SCAN(1026-CURPTR,=CHR(13),BUF[CURPTR]);

      (* Allow for lines of more than 255 characters *)
      IF I+LENGTH(S)>255 THEN
        I:=255-LENGTH(S);
      (* Move data from buffer to the string and set string length *)
      (*$R-*)
      MOVELEFT( BUF[CURPTR],S[LENGTH(S)+1],I);
      S[0]:=CHR(LENGTH(S)+I);
      (*$R+*)

      (* Increment character count and set mode flag *)
      CURPTR:=CURPTR+I+1;
      LASTMODE:=READMODE;
    END;
END;


PROCEDURE FASTWRITELN(VAR F:FILETYPE; S:BIGSTRING);

(*--------------------*)
(*  Do a 'WRITELN' for TEXT files *)
(*--------------------*)

VAR     I,NBK: INTEGER;

BEGIN
(* Insert a carriage return at end of string *)
S:=CONCAT(S,' '); S[LENGTH(S)]:=CHR(13);

(* Do space compression at first of string *)
IF LENGTH(S)>2 THEN
  BEGIN
    (* Scan for first non blank *)
    I:=SCAN(LENGTH(S),<>' ',S[1]);
    IF I>2 THEN
      BEGIN
        (* Compress space with DLE character and delete blanks *)
        S[1]:=CHR(16);
        S[2]:=CHR(32+I);
        DELETE(S,3,I-2);
      END;
  END
ELSE
  I:=0;

WITH F DO
  BEGIN
    LASTMODE:=WRITEMODE;

    (* See if buffer is full and needs to be written *)
    IF LENGTH(S)>1024-CURPTR THEN
      BEGIN

        (* Write current blocks out *)
        (*$I-*)
        NBK:=BLOCKWRITE(FL,BUF,2);
        (*$I+*)
          (* Check for no more room on the file *)
          IF (NBK<>2) OR (IORESULT<>0) THEN
            BEGIN
              ENDOFFILE:=TRUE;
              EXIT(FASTWRITELN);
            END;

          (* Move zeroes to the new buffer *)
          FILLCHAR(BUF,SIZEOF( BUFTYPE ),CHR(0));
          CURPTR:=1;
        END;

      (* Put string in buffer *)
      MOVELEFT(S[1],BUF[CURPTR],LENGTH(S));
      CURPTR:=CURPTR+LENGTH(S);
    END;
END;

PROCEDURE FASTCLOSE(F: FILETYPE);

(*--------------------*)
(*  Do a 'CLOSE' for TEXT files *)
(*--------------------*)

VAR     HEAPPTR: INTEGER;
        I: INTEGER;
BEGIN
  WITH F DO
    BEGIN
      (* Write last buffer if in 'WRITE' mode *)
      IF (LASTMODE=WRITEMODE) AND (CURPTR>1) THEN
        BEGIN
          (*$I-*)
          I:=BLOCKWRITE(FL,BUF,2);
          (*$I+*)
        END;

      (* Close file *)
      IF LASTMODE=WRITEMODE THEN
        CLOSE(FL,CRUNCH)
      ELSE
        CLOSE(FL,LOCK);

      (* Release file space if nothing else on the heap *)
      MARK(HEAPPTR);
      IF ORD(HEAPPTR)-ORD(FL)=SIZEOF( FILEOFTEXT )+SIZEOF( BUFTYPE ) THEN
        RELEASE(FL);
    END;
END;


(**************************************************************)
(*                                                            *)
(*        E N D   F A S T   I / O   P R O C E D U R E S       *)
(*                                                            *)
(**************************************************************)


(**************************************************************)
(*                                                            *)
(*   E X A M P L E   O F   C A L L I N G   F A S T   I / O    *)
(*                                                            *)
(**************************************************************)



BEGIN

  WRITE('INPUT FILE: ');
  READLN(FN);

                (*******************)
                (*                 *)
                (*     R E A D     *)
                (*                 *)
                (*******************)


(*------------*)
(* Demo showing speed of READLN on TEXT file *)
(*------------*)

(*$I-*)
RESET(OLDFILE,FN);
(*$I+*)
IF IORESULT<>0 THEN
  BEGIN
    WRITELN('IO ERROR');
    EXIT(PROGRAM);
  END;
```

Listing 1 continued on page 460

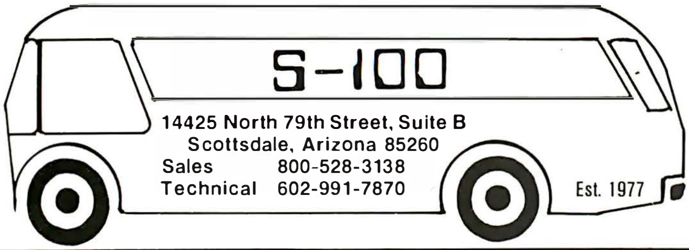
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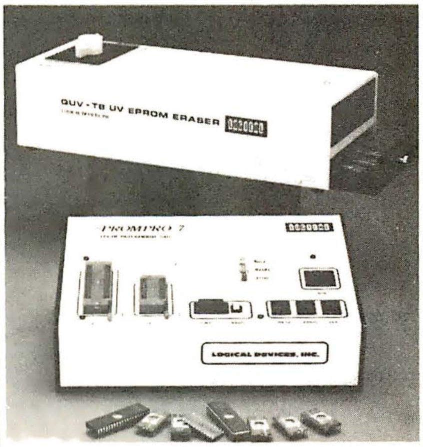
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74LS28	.32
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74LS37	.50
74LS38	.32
74LS42	.50
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74LS51	.24
74LS55	.35
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74LS83	.70
74LS86	.38
74LS90	.60
74LS91	.85
74LS92	.65
74LS93	.60
74LS95	.80
74LS107	.38
74LS109	.38
74LS112	.40
74LS113	.40
74LS114	.45
74LS122	.40
74LS123	.85
74LS125	.90
74LS126	.85
74LS132	.70
74LS136	.50
74LS138	.65
74LS139	.65
74LS145	1.10
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74S51	60
74S65	95
74S74	55
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74S86	1 10
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MC6800	7 75

Listing 1 continued:

```
WRITELN;
WRITELN(CHR(7),'PRESS KEY TO START STANDARD TEXT FILE READING');
READ(KEYBOARD,CH);

READLN(OLDFILE,S);
WHILE NOT EOF(OLDFILE) DO
  BEGIN
    WRITELN(S);
    READLN(OLDFILE,S);
  END;
CLOSE(OLDFILE,LOCK);


(*----------*)
(* Demo showing increased speed of FASTREADLN on TEXT file *)
(*----------*)

FASTRESET(FASTFILE,FN);
IF IORESULT<>0 THEN
  BEGIN
    WRITELN('IO ERROR');
    EXIT(PROGRAM);
  END;

WRITELN;
WRITELN(CHR(7),'PRESS KEY TO START FAST READ');
READ(KEYBOARD,CH);

FASTREADLN(FASTFILE,S);
WHILE NOT FASTFILE.ENDOFFILE DO
  BEGIN
    WRITELN(S);
    FASTREADLN(FASTFILE,S);
  END;
FASTCLOSE(FASTFILE);

                    (*******************)
                    (*                 *)
                    (*    W R I T E    *)
                    (*                 *)
                    (*******************)

WRITE('OUTPUT FILE: ');
READLN(FN);

(*------------*)
(* Demo showing speed of WRITELN on TEXT files *)
(*------------*)

(* Open a file named the user specified name with a 'S' in front to
   indicate 'standard' way of doing TEXT I/O *)
(*$I-*)
REWRITE(OLDFILE,CONCAT('S',FN));
(*$I+*)
IF IORESULT<>0 THEN
  BEGIN
    WRITELN('IO ERROR');
    EXIT(PROGRAM);
  END;

WRITELN;
WRITELN(CHR(7),'PRESS KEY TO START STANDARD TEXT FILE WRITING');
READ(KEYBOARD,CH);

FOR I:=1 TO 50 DO
  BEGIN
    WRITE('.'); (* Write a dot to show action on the screen *)
    WRITELN(OLDFILE,'RECORD NUMBER ',I:2,' ABCDEFGHIJKLMNOPQRSTUVWXYZ');
  END;
WRITELN('  DONE');

CLOSE(OLDFILE,LOCK);

(*------------*)
(* Demo showing increased speed of FASTWRITELN on TEXT files *)
(*------------*)

(* Open a file named the user specified name with a 'F' in front to
   indicate 'fast' way of doing TEXT I/O *)
FASTREWRITE(FASTFILE,CONCAT('F',FN));
IF IORESULT<>0 THEN
  BEGIN
    WRITELN('IO ERROR');
    EXIT(PROGRAM);
  END;

WRITELN;
WRITELN(CHR(7),'PRESS KEY TO START FAST WRITING');
READ(KEYBOARD,CH);

FOR I:=1 TO 50 DO
  BEGIN
    WRITE('.'); (* Write a dot to show action on the screen *)
    STR(I,STRINGI);
    WHILE LENGTH(STRINGI)<2 DO
      STRINGI:=CONCAT(' ',STRINGI);
    FASTWRITELN(FASTFILE,CONCAT('RECORD NUMBER ',STRINGI,
                                ' ABCDEFGHIJKLMNOPQRSTUVWXYZ'));
  END;

WRITELN('  DONE');

FASTCLOSE(FASTFILE);

END.
```


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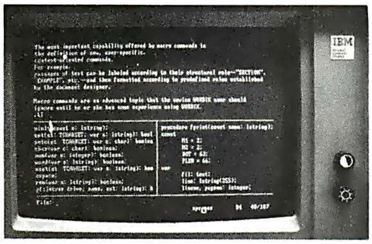
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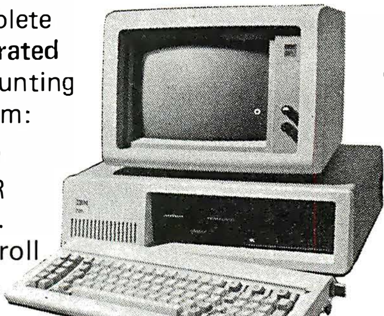
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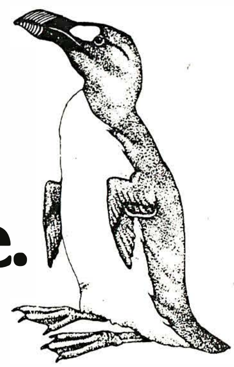
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Join an organization that's **doing** something about preserving our endangered species. Get involved. Write the National Wildlife Federation, Department 105, 1412 16th Street, NW. Washington, DC 20036.

It's not too late.

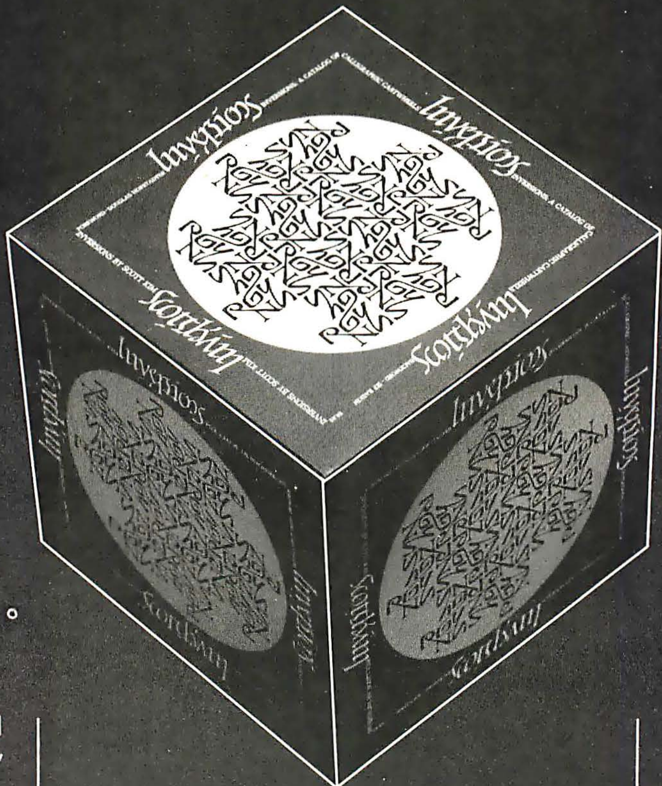
INVERSIONS

a catalog of calligraphic cartwheels
by Scott Kim

Foreword by
Douglas Hofstadter

Backword by
Jef Raskin

Inversions



Scott Kim

Illusion...calligraphy...visual magic—Scott Kim's new book, *Inversions*, delights the eye and enchants the mind. Filled with intriguing designs, words that read the same right-side up and upside down, words-within-words, and unexpected symmetries, these compositions create a fresh way to look at the alphabet. The text includes the visual principles of symmetry, lettering, and problem solving that are basic to these images. The author also draws parallels to related exercises in perception in such diverse areas as art, music, word play, and mathematics. Scott Kim's original inversion designs first appeared in *Omni* magazine, inspiring an overwhelming reader response. An irresistible challenge, invertible writing appeals to everyone who loves beauty in mathematics and design. Scott Kim is a doctoral student in Computer Science at Stanford University.

"Kim is the Escher-of-the alphabet. He has created a new art form that blends beauty and ingenuity and has made it so clear to us that we can try it ourselves if we so desire. It may well become the new amusement of the literate." **Issac Asimov**

"Scott Kim has perfected a personal art form—one with grace, elegance, subtlety, and surprises."
Douglas Hofstadter, author
Gödel, Escher, Bach: an Eternal Golden Braid

"...sure to dazzle and delight anyone to whom writing is dear."
The New York Times Book Review

"Scott Kim's *Inversions*...is one of the most astonishing and delightful books ever printed."
Martin Gardner Scientific American

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BYTELINES

News and Speculation about Personal Computing

Conducted by Sol Libes

Random Rumors: Next month, Epson is expected to introduce the FX-80, the replacement for the MX-80 dot-matrix printer. The MX-80 had captured an estimated 40 percent of the world market for low-cost printers. The FX-80 is expected to operate at a much higher speed and will include some new features. Epson also plans to unveil a new low-cost printer sometime soon. . . . It's rumored that Hewlett-Packard will soon introduce a more elaborate version of its HP-75 portable computer. . . . This year, expect to see the merger and acquisition of several software companies. . . . A version of Microsoft's Xenix operating system (itself a version of the Unix operating system created years ago at Bell Laboratories) is reportedly in development for the IBM Personal Computer. Incidentally, two single-user Unix-like packages are already available for the IBM Personal Computer, as previously reported in this column (see the October 1982 BYTE, page 456). . . . TI (Texas Instruments) is expected to introduce a family of handheld and portable microcomputers, starting with an under-$100 unit, during the first quarter of this year. . . . Mattel, which introduced a personal computer two years ago that had a less-than-sensational impact on the market, is expected to make a second attempt this year. . . . Analysts are predicting the imminent introduction of a 100-megabyte 5¼-inch Winchester-type hard-disk drive. The greatest capacity presently available is 80 megabytes. . . . Sony is expected to introduce shortly a 16-bit system using CP/M. . . . Expect the following Japanese companies to introduce 16-bit systems into the U. S. this year: Mitsubishi, Sord, Toshiba, Matsushita, Hitachi, and Sanyo. Most are expected to be software compatible with the IBM Personal Computer.

The Changing Scene: Last year marked a dramatic change in the personal computer market: what was once a hobbyist-dominated market is now geared primarily toward businesses. In the early and mid 1970s, personal computer use was dominated by people interested in experimenting in hardware; they formed a small and determined group that pioneered the field. The late 1970s saw the introduction of integrated hardware/software systems such as the Radio Shack TRS-80, the Commodore PET, and the Apple II, as well as an emphasis shift toward the software experimenters, who were still primarily hobbyists.

Last year saw personal computer sales move well past the billion-dollar mark; large and well-established companies such as IBM and DEC (Digital Equipment Corporation) entered the market. Personal computers no longer make up one market but several, with products ranging from the low-cost, appliance-type computers being merchandised like any other appliance to computers intended for small businesses and to the workstations sold by the hundreds to the larger businesses.

The hobbyists are still there, and their numbers are growing, but now they are a minor factor in the industry they created, just as the radio amateurs are long forgotten for the industry they created and pioneered. Although I am amazed at what we are doing with microcomputers today, I still occasionally look back with tender feelings to the early days, to the camaraderie of hobbyists helping one another to learn and explore together. I wonder about the big, competitive, impersonal business that personal computing is becoming.

Sinclair News: It is estimated that over 600,000 Sinclair ZX81 and Timex/Sinclair 1000 computers have been sold already and that the total may reach 1 million by year-end. About 40 percent of the sales were in the U. S. This month Sinclair will cease all mail-order sales of the ZX81 in North America, and the computer will be available only as the Timex/Sinclair 1000. The agreement between Sinclair and Timex called for all mail-order sales to cease when sales of the Timex/Sinclair 1000 reached 75,000 units. The mail-order sales included both those sold directly by Sinclair and those sold by American Express. It's estimated that American Express sold some 70,000 units. Timex will pay Sinclair a 5 percent royalty on all hardware and software sold. The Timex/Sinclair 1000 has a $100 list price, but I have already seen the unit discounted to $79.95. Sinclair continues to sell it outside North America.

The Sinclair Spectrum computer, which I covered in an earlier column (see the September 1982 BYTE, page 490), is expected to be introduced shortly in the U. S. It has been available in England for over seven months; however, the under-$100 disk-drive announced for it is still not available. Sinclair is expected to sell the 16K-byte Spectrum initially through mail order in the U. S.; the price will be well under $200, as competitive units already sell for $200 or less. A 48K-byte version is expected to sell for about $275. The Spectrum is selling extremely well in the United Kingdom and has a typical back-order delay of three months. Sinclair is also expected to introduce its flat-screen television into the U. S. this spring.

Commodore News: Commodore is believed to be ready to introduce a 3-inch micro-floppy-disk drive for the VIC-20; the unit is being manufactured in Hungary and will store 150K bytes of data. The drive is also expected to appear in products from Tandy and possibly Apple. Commodore's new 16-bit microprocessors appear to have run into some development snags; there still is no word on when samples will be available.

Commodore's new C64 computer, which the company is promoting heavily in magazine advertisements, reportedly offers a CP/M option and thus the availability of several thousand CP/M application programs; however, this product does not appear close to release and no mention is made as to how users will obtain the

← Circle 504 on inquiry card.

software in the Commodore disk format. The latter point has become a serious problem for users of other machines who have bought so-called CP/M options only to find that most of that wonderful CP/M software is available only on 8-inch, IBM-format, single-density disks.

IBM Happenings: Sales of under-$500 home computers are expected to exceed $1 billion this year, and it's believed that IBM will enter this segment of the market. This month, IBM will exhibit at the CES (Consumer Electronics Show) in Las Vegas. CES is oriented to dealers of such mass-market products as video games, electronic toys, etc., and it is unlikely that attendees would be interested in the likes of the IBM Personal Computer, which in some configurations sells for close to $5000.

IBM has taken a very large exhibit space at the March 1983 West Coast Computer Faire, to be held in San Francisco. Speculation has it that IBM will introduce there a new, upgraded version of its Personal Computer using the Intel 80186 or 80188 microprocessors. These devices are expected to significantly improve the system's performance while reducing the IC (integrated circuit) count by about 20 and possibly reducing the cost of the basic unit to under $1000. Also, Intel has introduced the 80286 version of its 8086 microprocessor, with performance equal to or better than the Motorola 68000 family; it's rumored that IBM may introduce an enhanced Personal Computer using this device. This modification would increase the Personal Computer's performance about six times and would probably double its cost. One feature sure to be added is multitasking.

Dynalogic Info-Tech Corporation, Ottawa, Canada, boasts that it will be the first company to introduce an IBM Personal Computer look-alike. Priced at $4995, the system will include 256K bytes of memory, dual floppy-disk drives, a built-in video monitor, and a modem. Software will be available, and the unit will be portable a la the Osborne 1. An IBM Personal Computer look-alike is also expected shortly from Hitachi; however, it is expected to offer better graphics, have more storage space, and cost more than IBM's system.

Also, IBM fired three employees and accused them of stealing information about new personal computer products that IBM was developing. The three were accused of forming a company through which they were funneling advance information to suppliers of IBM peripherals products and also of intent to market such products through the company. Two of the former employees were supposedly the leading designers of the IBM Personal Computer.

Apple Doings: Apple Computer Inc. is now shipping an estimated 20,000 Apple II and 3000 Apple III computers per month. The sales of the Apple II have been holding level for the last several months. Sales had begun to falter in the spring as competition from the IBM Personal Computer increased; however, a drop in price brought Apple II sales back up. Sales of the Apple III, which is purchased primarily by businesses, increased when IBM introduced the Personal Computer, probably due to the resulting increased ac-

ceptance of personal computers in business. Perhaps Apple should thank IBM for legitimizing the use of personal computers in the office.

Giveaway Computers: Personal computers have become the latest thing in premiums. A home builder in Naperville, Illinois, is giving away an Apple II computer to each home buyer; in Columbus, Ohio, a furniture dealer is offering a free Timex/Sinclair 1000 with each furniture purchase over $799.

Radio Shack News: It is now over 10 months since Radio Shack announced its dual-processor, multiuser Model 16, and the company has yet to deliver the promised operating system and languages that take advantage of the Motorola 68000 processor. Softworks Limited, a small software house in Chicago, has already beaten Radio Shack to the punch by introducing some languages for the unit, but for the most part purchasers of the Model 16 have been compelled to use the existing Z80-based, single-user software originally designed for the Model II. It's rumored, however, that Microsoft has developed a Unix-like, three-user operating system for the Model 16 and that its introduction is expected momentarily.

It is estimated that Tandy has sold over 3000 Model 16s. Jon Shirley, Tandy's vice-president of computer merchandising, has stated that "we have more 68000 machines in the field than anyone." Of course, he ignored the fact that the machines are all using the 8-bit Zilog Z80 coprocessor and not the 16-bit 68000 processor.

Matra S. A. of France has signed an agreement with Tandy to manufacture TRS-80 Model III computers in France.

Price Wars Intensify: Competition among suppliers of computers selling for under $300 intensified over the summer as price cuts, rebates, and giveaways of software packages were offered by TI (Texas Instruments), Commodore, and Atari. Dealers have cut their own margins so that actual selling prices have moved to under $200.

In the $400-to-$1000 price range, Atari increased the memory size of the Atari 800 from 16K bytes to 48K bytes, yet the unit's list price remained at $899, and the dealer price stayed at $625 (many dealers have discounted the selling price to under $700). The net result is that these systems, complete with display and two disk drives, now sell for less than $2000.

In the under-$2000 market, the Osborne 1, Kaycomp Kaypro II, Morrow Decision 1, and Cromemco C-10 are all selling for under $1800 and include much software that users have to pay extra for on the Atari, Apple, Radio Shack, and Commodore systems. It is expected that Osborne will soon reduce its price to under $1600, which is expected to initiate a new round of price cuts.

Store Numbers Are Declining: The number of independent computer stores has been declining over the past year. Industry experts contend that this is due to business failures and that only a small number of the stores are showing a decent profit. Computer store dealers are finding that the lower-cost systems are difficult to sell due to competition from mass-merchandisers and mail-order discounters, who have cut prices tremendously. The result is that the stores are generally shying away from sales of home-style systems and are moving to the larger, more expensive business-oriented systems where the customer is more concerned with support. Industry experts are predicting that the number of independent computer stores may drop to half their current number within the next five years. (Incidentally, Tandy already has 330 Radio Shack computer centers in operation, with more to come.)

In the meantime, Computerland, with over 300 franchised computer stores (60 outside the U. S.), is encouraging its dealers to open satellite stores to sell packaged software and supplies to home computer users in high-traffic areas. They will provide little in the way of support. Customers requiring support and anyone wishing to purchase systems for other than game applications will be referred to the main store. Computerland expects to open 15 new franchises per month this year. A Computerland franchise costs between $100,000 and $250,000 depending on location and inventory. Computerland then takes an 8 percent royalty on each sale, plus 1 percent of the sale for advertising.

Store growth is also expected in another new area: that of computer service stores. Currently several nationwide service organizations provide service support for many manufacturers of microcomputer systems. Sorbus Service, second largest of the independent computer-maintenance concerns, has already opened stores in Los Angeles, Chicago, and Philadelphia. TRW (the largest firm in computer maintenance) plans to open its first store in Dallas. Globuscope Inc., a New York photo-equipment company, plans to shortly open its first Computer Doctor store in New York City. RCA and Western Union are also seriously considering opening service stores.

These "third-party" maintenance companies came into existence to service large computers and last year grossed over $500 million. With the expansion into carry-in stores, they are looking to expand their business to over $1 billion this year. Much of their business is also expected to come from computer retail stores.

New Microprocessors: Compupro of Oakland, California, takes the prize as the first U. S. personal computer supplier to introduce a processor board using the new National Semiconductor 16032 microprocessor and the first to show a board using the Intel 80286 16-bit microprocessor. Both are on S-100/IEEE-696 cards and operate at 10 MHz. Both also have sockets for optional floating-point and memory-management coprocessors. Compupro is furnishing FORTH and a macroassembler for the 16032, and if Digital Research proceeds with its tentative plans, a version of CPM-86 will be available for the 80286. It's hinted that versions of Unix will be available for both.

Micro-Floppy Standard: A tentative accord appears to have been reached between several U. S. and European disk-drive and disk-media suppliers to adopt a standard based on the Sony 3½-inch floppy-disk. Included in the accord are Shugart Associates, Micro Peripherals, and Verbatim. A standard has been submitted to an ANSI (American National Standards Institute) committee that calls for the Sony disk to be made similar to the existing 5¼-inch floppy disks, having 40 or 80 tracks per side and being single- or double-sided. An 80-track double-sided drive would have a 1-megabyte capacity.

Shugart disclosed that it expects to start shipping sample drives compatible with this standard shortly, at a volume price of under $100 a piece. Volume production is expected toward the end of the year. The other companies who participated in the drafting of the standard include Olivetti, BASF, Xidex, and Brown Disc. Sony, however, has asked the ANSI committee to accept its basic 3½-inch design, rather than that proposed by these companies. The Sony disk is the same in all respects except that it uses a thicker medium and faster rotational speed.

SIG/Disabled Founded: The San Diego Computer Society has begun a SIG

(special interest group) for disabled individuals. The SIG presently has 50 members organized into 6 subgroups: communications (networks, etc.), education, home environmental control, career/job enhancement, introduction to computers for novices, and problem solvers. Of the group members, 25 percent have some type of disability. For information contact Barbara E. Sack, 2596 Escondido Ave., San Diego, CA 92123.

AMRAD (Amateur Radio Research and Development Corporation), a group of radio amateurs, is also very active in the area of communications for the physically disabled. For information write to AMRAD, 1524 Springvale Ave., McLean, VA 22101.

Software Legislation: The House Subcommittee on Courts, Civil Liberties, and Administration of Justice is considering legislation for software protection. If passed, the new law will amend the federal Copyright Act as to the definition of computer software and will emphasize that reliance on copyright protection in no way precludes any state trade-secret protection. Also, the use of a copyright mark on unpublished software will not constitute publication. The user will have to deposit the computer software with the Copyright Office in the same manner as printed material.

Computer Games: It is estimated that Atari has shipped 6 million video-game units so far and grossed over a billion dollars from sales (that doesn't include game cartridges). Atari has about 75 percent of the video-games market, while Mattel has about 15 percent; the remainder is shared by Coleco, Astroarcade, and Emerson Radio.

After several years of skyrocketing growth, sales of video-game units are expected to grow at a much more moderate rate. This is because personal computers are now selling in the same price range and offer other benefits besides the ability to play games. Thus, game manufacturers such as Atari and Mattel have begun to slash prices and offer rebates. Atari is expected to introduce a new game unit with powerful graphics at a price well under $200, while previous plans had called for a price over $250.

Similarly, Commodore, which had previously announced a target price of $180 for its new Max game unit, is expected to drop the price to $150 when the unit finally appears on dealers' shelves. Game-cartridge suppliers such as Parker Bros., Imagic, and Activision, which previously supplied cartridges only for game units, are expected to start supplying their game cartridges for personal computers as well.

Videotex Starts in U. S.: In Great Britain, where the videotex idea started, the Prestel system, after one year of operation, has revealed that 85 percent of its customers are businesses, not the individual consumer (for whom the system was originally designed). It is estimated that there are already 775,000 Prestel, Viewdata, and Teletext sets in operation in 15 countries.

In the United States, AT&T—together with CBS-TV—is conducting a test of videotex involving 200 homes. IBM has announced a private videotex system called SVS/1. Chemical

Bank, in New York City, has inaugurated a home-banking system for users of Atari 400 personal computers that will be expanded to include other videotex services.

Basically, two different types of videotex services are envisioned: one for use by individual consumers, and another that is operated as a private, in-house business system. The IBM system appears aimed at the latter category. Modular Computer Systems, Fort Lauderdale, Florida, and Rediffusion Computers Ltd., Sussex, England, also are manufacturing private business systems. Further, Tandy has announced a private videotex system, although the company has not yet delivered any units. Wolfdata, of Ithaca, New York, already offers a videotex system based on IBM Personal Computer systems.

The private business systems generally rely on the telephone lines for communications, although some are using video-cable systems. The consumer systems use either telephone or cable and rely on the TV receiver for display. In the AT&T tests, 1200-bps (bits per second) modems are used. Half of the homes use a special keyboard and television receiver while the other half are using complete video terminals. Both systems provide a graphics display that updates rapidly using algorithms that replace only those elements in the display that change.

Random News Bits: Intel is the first company to introduce VLSIC (very-large-scale integrated circuits) to interface computer equipment to Ethernet local-area networks. Expect 3Com Corporation of Mountain View, California, to introduce shortly its set of integrated circuits. With the availability of these devices, we can expect to see Ethernet options being offered soon on many personal computers. . . . Okidata Corporation has ceased manufacturing printers in the U. S. and will now limit itself to importing products from its Japanese parent. . . . National Public Radio and the National Information Utilities Corporation have formed INC Telecommunications to develop the delivery of data via network-based FM (frequency modulation radio) subcarriers. . . . Design Aids Inc., Laguna Niguel, California, has introduced a talking drafting system. The user sketches a drawing and then, with the aid of a digitizer and voice-feedback prompts via headphones, enters the data to the IBM Personal Computer. Cost is $19,000. . . . Intel has introduced a 64K-bit (8K- by 8-bit) intelligent dynamic memory IC called the iRAM2186 that interfaces as easily as a static memory IC. . . . DEC has cut the price of its VT-100:CP/M upgrade from $2400 to just under $1300. That's quite a price cut. . . . Toshiba has unveiled a 3½-inch floppy-disk drive capable of storing 3 megabytes on a single side; its introduction is expected late next year. . . . Tandy has bought the remaining 50 percent of Datapoint's share in Texas Peripherals, a floppy-disk manufacturer. The firm is a primary supplier of floppy-disk drives for Radio Shack computers. . . . The IEEE (Institute of Electrical and Electronics Engineers) Microprocessor Standards Committee has established a group to develop a standard for the STD-type bus using 100- by 160-mm Eurocards and DIN (Deutsche Industrie Norm) 41612-C 64-way connectors. . . . Motorola has introduced a CMOS (complementary metal-oxide semiconductor) version of the 6809 microprocessor, perhaps the most powerful 8-bit microprocessor currently in production.

MAIL: I receive a large number of letters each month as a result of this column. If you write to me and wish a response, please include a self-addressed, stamped envelope.

Sol Libes
c/o BYTE Publications
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Hancock, NH 03449 ■

BYTE's Bits

Dow Jones Expands Services

The complete 20-volume *Academic American Encyclopedia* can now be accessed by subscribers of the Dow Jones News/Retrieval service. Produced by Grolier Electronic Publishing, the encyclopedia has 9 million words and more than 28,000 articles indexed by subject. The encyclopedia will be updated twice a year and can be searched using keywords. In addition, lists of cross references are provided.

Dow Jones is also making available a movie review database to its News/Retrieval subscribers. This service, manufactured by Cineman Syndicate of Middletown, New York, provides brief plot descriptions of some 50 films, rated on a scale ranging from great to poor. Contact Dow Jones & Co. Inc., 22 Cortlandt St., New York, NY 10007, (212) 285-5466.■

Clubs and Newsletters

SD-ACE News and Meetings

San Diego Atari Computer Enthusiasts (ACE) is a nonprofit organization and users group not connected with the Atari Corp. All meetings are held at 6:30 p.m. on the third Monday of each month in the Social Room of the North Park Recreational Center, 4044 Idaho St., San Diego, California. A $5 membership fee includes free access to the SD-ACE computer program library, class information, and a subscription to the group's newsletter. Address inquiries to Dick Hiatt, President SD-ACE, 5353 Baltimore Dr. #39, La Mesa, CA 92041.

TI Users in Southwestern Ohio

The TI 99/4 Users Group of the Cincinnati-Dayton area produces the monthly *Cin-Day Users Group Newsletter.* Subscriptions to the newsletter and other mailings are $5 per year for nonmembers. For further information, contact The 99/4 Users Group of the Cincinnati-Dayton Area, 11987 Cedarcreek Dr., Cincinnati, OH 45240.

Apple Readers

The Rainbow's Edge is a newsletter for Apple Computer users published by Rainbow Computing Inc. It includes product descriptions, articles, and reviews. Send $1 ($2 outside the U.S.) to Rainbow Computing, 19517 Business Center Dr., Northridge, CA 91324, or call (213) 349-0300 Tuesdays through Fridays.

From Tulsa, Oklahoma

The I/O Port is the official monthly newsletter published by the Tulsa Computer Society, a nonprofit, educational corporation. The $6 annual membership fee includes a one-year subscription to *The I/O Port.* The Tulsa Computer Society meets on the last Tuesday of each month at 7:30 p.m. in the Tulsa Vocational-Technical School seminar center at 3420 South Memorial Drive in Tulsa. For further information, write to the Tulsa Computer Society Inc., POB 1133, Tulsa, OK 74101.

New Jersey Meetings Planned

The Computer Club of Ocean County is a nonprofit organization in New Jersey with plans to publish a periodic newsletter and sponsor specialized tutorials, seminars, and workshops. Meetings are scheduled for the first Friday of each month and the proposed agenda includes speakers and demonstrations. Annual dues are $9, payable in September of each year. For further information, write to Gerry Wagner, 1104 Aspen Dr., Toms River, NJ 08753, or call (201) 349-6070.

Intercalc Serves Spreadsheet Users

Intercalc, an independent, international users group, focuses on the use of Visicalc-type programs. Intercalc also publishes *Spreadsheet,* a bimonthly newsletter. It includes tips, programs, applications, and questions and answers relevant to electronic spreadsheet programs. Membership dues are $25 per year and include *Spreadsheet.* For more information, contact Intercalc at POB 254, Scarsdale, NY 10583.

Consulting Computerists

The Independent is the newsletter of the Independent Computer Consultants Association (ICCA). It is published six times a year and contains information pertinent to computer consulting. Coverage is extensive as there are seventeen chapters of the ICCA located in major American cities. For further information, write to the ICCA, POB 27412, St. Louis, MO 63141, or call (314) 567-9708.

Pomona Heath Users Group

The Pomona, California, Heath Users Group (HUG) meets on the fourth Thursday of each month at 7:30 p.m. at the Heathkit Electronic Center in Pomona. For more information, write to Pomona HUG, H. Friedman, 1555 North Orange Grove Ave., Pomona, CA 91767.

6809 and OS-9 Users Unite

A users group for people interested in the 6809 processor, the OS-9 operating system, and Unix-like systems on the 6800 series of microcomputers is forming. Goals include a public-domain software library, a commercial-software registry, and a periodical to be either in print or on electronic media. Anyone interested in participating in the formation of this users group may contact one of the following provisional officers: Brian Capouch, RR 1, Box 270, Monon, IN 47949; Shel Epstein, Box 400, Wilmette, IL 60091; Howard Harkness, POB 28954, Dallas, TX 75228; or Erwin Straehley, 1005 Roble Lane, Santa Barbara, CA 93103.

An IBM Users Group Has News and Hotline

A worldwide IBM Small Systems Users Group represents owners, users, schools, and third-party software professionals on all IBM Small Systems (the Personal Computer, Datamaster, 5120, S/34, and the Displaywriter). The group publishes *Basic Society News* monthly, sponsors local Basic Society chapters, and belongs to a software-source hotline. Annual membership is $25. For more information, contact Kathy Ames, Basic Society Inc., POB 345099, Dallas, TX 75234, or call (214) 484-9900.

Portland Computer Society

The Portland Computer Society meets every third Saturday and publishes a monthly newsletter. To keep informed with its calendar of events, book reviews, and articles, write to Ted Peterson, W7WWG, POB 230221, Portland, OR 97223.

Jinsam Newsletter

Jinsam Newsletter, a publication of Jini Micro-Systems, provides news releases and accounts of applications of the Jinsam Executive database management system. Annual subscriptions are $5 in the U.S. and $8 internationally. For more information, contact Jinsam Newsletter, Jini MicroSystems Inc., POB 274 Kingsbridge Station, Riverdale, NY 10463.■

Event Queue

January 1983

January
Intensive Seminars for Professional Development, Worcester Polytechnic Institute campus and various sites in the New York City and Boston metropolitan areas. Some of the topics to be presented are "Project Management," "Leadership Skills and Management Tools for High-Technology Professionals," and "Management Skills for First-Line Supervisors." Fees range from $495 to $990. Complete details are available from Ms. Ginny Bazarian, Office of Continuing Education, Higgins House, Worcester Polytechnic Institute, Worcester, MA 01609, (617) 793-5517. For information on in-house seminars, call Robert J. Hall at (617) 793-5574.

January
Courses from Q.E.D. Information Sciences, various sites throughout the U.S. Among the courses offered are "Project Management and Control," "Teleprocessing Network Design," and "Leadership: Managing and Influencing People." Complete course outlines are available from Priscilla Goudreault, Q.E.D. Information Sciences Inc., Q.E.D. Plaza, POB 181, Wellesley, MA 02181, (800) 343-4848; in Massachusetts, (617) 237-5656.

January-February
Seminars of Interest to Women Professionals, various sites in the New York City and Boston metropolitan areas. This series of one- and two-day seminars is presented by Boston University Metropolitan College. Among the topics on the agenda are "Tactical Innovations in Marketing Management," "Advanced Management for Women: Beyond the Basics," and "Data Processing Fundamentals for Accounting and Financial Managers." The seminar fees are $325 and $495, depending on duration. For registration information, contact Ms. Joan Merrick, University Seminar Center, Suite 415, 850 Boylston St., Chestnut Hill, MA 02167, (617) 738-5020.

January-March
Courses for Developers and Users of Computer Systems, various sites throughout the U. S. Among the courses offered by the AMA (American Management Associations) are "Fundamentals of Data Processing for the Nondata Processing Executive," "BASIC: A Computer Language for Managers," and "Database Concepts and Design." For complete registration and course information, contact the AMA, 135 West 50th St., New York, NY 10020, (212) 586-8100.

January 11-12
Local Area Networks: Architecture, Technology, and Products, Sheraton-Tara Hotel, Framingham, MA. Topics to be covered at this workshop include network concepts and architectures, local-network characterization, internetworking, and standards. The registration fee is $570. For further information, contact Technology Concepts Inc., 730 Boston Post Rd., Sudbury, MA 01776, (617) 443-4637.

January 11-13
Unix Hands On, Atlanta, GA. This seminar will provide a detailed overview of the Unix operating system. Hands-on experience will be offered. Unix System III, Version 7, and the UC (University of California) Berkeley enhancements will be covered. The course fee is $850. For further information, contact Cardinal Information Systems, POB 97, Dayton, OH 45449, (513) 435-4653.

January 12-14
Designing Systems Controls, New York, NY. This course explains what systems controls are, why they are important, and how they can be analyzed and evaluated. It is developed for managers, designers, and analysts actively involved in new systems controls. Further details are available from Q. E. D. Information Sciences Inc., Q. E. D. Plaza, POB 181, Wellesley, MA 02181, (800) 343-4848; in Massachusetts, (617) 237-5656.

January 13
Network Optimization and Tariff Impact Strategies, San Francisco, CA. This seminar will provide a concise overview of how to maximize network potential and plan corporate strategies to minimize the impact of tariff increases. Contact the DMW Group Inc., Publishing and Seminar Division, 2020 Hogback Rd., Ann Arbor, MI 48104, (800) 521-7802; in Michigan, (313) 971-5234.

January 18-19
Local Area Networks: Architecture, Technology, and Products, Berkeley Marina Marriott Inn, Berkeley, CA. For details, see January 11-12.

January 18-20
Microcomputers in Education, Tallahassee, FL. This workshop is designed for the professional development of educators at all levels. Topics to be covered include BASIC and graphics, Logo, administrative uses of microcomputers, and microcomputers as laboratory instruments. Hands-on experience with a variety of computers will be provided. Information is available from Ms. Sharon Woodruff, Technical Education Research Centers, 8 Eliot St., Cambridge, MA 02138, (617) 547-3890.

January 18-20
Southcon/83, High-Technology Electronics Exhibition and Convention, Georgia World Congress Center, Atlanta, GA. A few of the topics to be covered include aerospace electronics, defense electronics, and energy. For further information, contact Electronic Conventions Inc., 999 North Sepulveda Blvd., El Segundo, CA 90245, (800) 421-6816; in California, (213) 772-2965.

January 18-20
Unix Hands On, Orlando, FL. For details, see January 11-13.

January 18-21
Defining Software Requirements, Specifications, and Tests, San Diego, CA. Participants in this short course will learn how to analyze and document end-user requirements, generate software requirements that include test plans, and plan the sequencing of test and integration procedures. The fee is $845. Further details are available from Ruth Dordick, Integrated Computer Systems, 3304 Pico Blvd., POB 5339, Santa Monica, CA 90405, (213) 450-2060.

January 19-24
NAVA '83/COMMTEX International, Louisiana Superdome, New Orleans, LA. This communications and information technology exposition will feature seminars, specialized conferences, and the annual convention of the Association for Educational Communications and Technology. Seminar topics will cover

audio-visual management, new technologies of instruction in education and training, and audio-visual applications for trade, professional, and corporate communicators. More than 400 manufacturers and producers will display communications products, including audio-visual, video and microcomputer equipment, accessories, and software. For further details, contact the National Audio-Visual Association, 3150 Spring St., Fairfax, VA 22031, (703) 273-7200.

January 20
The Annual Janus Seminar, Sheraton Center, New York, NY. This year's seminar will focus on the marketing of information services. Panelists and speakers will address marketing issues from various aspects of information services, including online searchers, information brokers, and database or printed material producers. This event is cosponsored by the Metropolitan New York Chapter of the American Society for Information Science and the New York Chapter of the Special Libraries Association. For further details, contact Carol Tschudi, Engineering Societies Library, 345 East 47th St., New York, NY 10017, (212) 705-7610.

January 20-21
The Twelfth Annual National Measurement Science Conference and Exhibition, Hyatt Rickeys Hotel, Palo Alto, CA. This conference is developed for managers, scientists, engineers, and operating personnel. With "Accuracy and Automation" as the theme, seminar sessions will stress practical applications of new equipment and techniques to solve measurement problems. By format and objective, this conference will promote professional and state-of-the-art approaches, and emerging technologies in the fields of measurement science. For registration information, contact Bob Weber, Lockheed Missile & Space Corp., Sunnyvale, CA 94046, (408) 742-2957.

January 21-23
CP/M '83, Moscone Center, San Francisco, CA. This international exposition and conference is designed for CP/M manufacturers, software developers, distributors, and users. The exposition is expected to be one of the largest presentations of CP/M-based hardware and software ever assembled. Seminars and conferences will explore CP/M applications, technical information, development aids, venture-capital programs, and software distribution. Adam Osborne, Chris Morgan, Tony Gold, Sol Libes, and Gary Kildall have assisted in organizing this show for Digital Research Inc. Contact National Computer Shows, 824 Boylston St., Chestnut Hill, MA 02167, (800) 343-2222; in Massachusetts, (617) 739-2000.

January 24-25
Computers in Agriculture Conference and Trade Fair, Red Lion Inn, Sacramento, CA. This conference and exhibition is designed to address the needs of farmers and ranchers in the West. More than 20 speakers and 60 hardware and software exhibitors will attend. The conference seeks to answer basic questions confronting farmers and ranchers considering the purchase of a computer. For details, write to Kim Schnoor, Western Agricultural Chemicals Association, Suite 209, 6650 Belleau Wood Lane, Sacramento, CA 95831.

January 24-26
Unix Hands On, Dallas, TX. For details, see January 11-13.

January 25-27
The First Annual Automated Office Expo, Moscone Center, San Francisco, CA. This show will feature computer and telecommunications systems, graphics, peripherals, and word-processing systems. This show is sponsored by *Infosystems* magazine. Contact Automated Office Expo, Suite 400, 222 West Adams St., Chicago, IL 60606, (800) 621-2134; in Illinois, (312) 263-3131.

January 25-28
Designing Real-Time Hardware for Digital Signal and Image Processing, Los Angeles, CA. Participants in this short course will learn how to implement digital filters, fast Fourier transforms, correlation, modulation, and other real-time processes by designing with general-purpose 16-bit microprocessors. Case histories and lectures will be featured. The fee is $845. Contact Ruth Dordick, Integrated Computer Systems, 3304 Pico Blvd., POB 5339, Santa Monica, CA 90405, (213) 450-2060.

January 31-February 2
Communication Networks '83, the Rivergate, New Orleans, LA. This fifth annual conference and exposition will encompass the voice, data, and telecommunications industry with sessions and demonstrations. The theme is "Communications Cost Control Via High Technology." Topics on the agenda include electronic mail and office communications, local-area networks and internetting, and modems and multiplexers. Optional in-depth skill seminars will be held. These seminars, led by industry leaders, include lectures, class activities, and a workbook. The general registration fee is $395; skill seminars cost $295. Contact Louise Myerow, Conference Management Group, CW Communications Inc., POB 880, Framingham, MA 01701, (800) 225-4698; in Massachusetts, (617) 879-0700 collect.

January 31-February 2
Telefile User Group Winter Conference, Queen Mary Hotel, Long Beach, CA. This conference is for members of the Telexchange, a group for Telefile and Xerox/Sigma computer users. For further details, contact Brian Edens, Telexchange secretary/treasurer, 17131 Daimler St., Irvine, CA 92714, (714) 557-6660.

February 1983

February
Continuing Engineering Education, George Washington University, Washington, D C, and the Hilton Inn Florida Center, Orlando, FL. Among the courses being offered are "Computer Graphics Systems: Design and Applications," "Configuration Management of Software Programs," and "Selecting Small Computers for Business and Government." Course fees range from $685 to $855. Course outlines are available from Douglas Green, Continuing Engineering Education, George Washington University, Washington, D C 20052, (800) 424-9773; in the District of Columbia, (202) 676-8515.

February 1-3
Unix Hands On, Houston, TX. For details, see January 11-13.

February 1-4
Advanced Microprocessor Programming and Applications Techniques, Los Angeles, CA. This short course is designed to teach participants how to use real-time operating systems, design customized modules to implement

real-time functions, apply 16-bit microprocessor families, and how to structure multiprocessor and multicomputer architectures. The fee is $845. Contact Ruth Dordick, Integrated Computer Systems, 3304 Pico Blvd., POB 5339, Santa Monica, CA 90405, (213) 450-2060.

February 1-4
Defining Software Requirements, Specifications, and Tests, Washington, D C. For details, see January 18-21.

February 3-6
The Rocky Mountain Regional Computer Show and Software Exposition, Denver Merchandise Mart, Denver, CO. This show features business computers, video games, and home computers. Admission is $5 for adults and $3 for children. For more information, contact Northeast Expositions, 824 Boylston St., Chestnut Hill, MA 02167, (617) 739-2000.

February 7-9
Microcomputers in Education, Washington, D C. For details, see January 18-20.

February 8-9
Local Area Networks: Architecture, Technology, and Products, Hyatt Regency Hotel, Atlanta, GA. For details, see January 11-12.

February 15-18
Peripheral Array Processors for Signal Processing and Simulation, University of California, Los Angeles. The fee for this course is $845. Contact Marc Rosenberg at the UCLA Extension, Continuing Education in Engineering and Mathematics, 6266 Boelter Hall, Los Angeles, CA 90024, (213) 825-1047.

February 15-18
Designing Real-Time Hardware for Digital Signal and Image Processing, Washington, D C. For details, see January 25-28.

February 16-18
The Third Annual TALMIS, Ambassador West, Chicago, IL. This conference brings together software publishers and users of microcomputer-based training systems. Issues on the agenda include the home market, local networking, new hardware, and successful distribution channels. Question-and-answer sessions will be held. Further information is available from Mary O'Keefe, TALMIS Inc., 115 North Oak Park Ave., Oak Park, IL 60301, (312) 848-4000.

February 16-19
Data and Telecommunications/Japan Exposition '83, Tokyo Ryutsu Centre, Tokyo, Japan. For information contact Cahners Exposition Group, Cahners Plaza, 1350 East Touhy Ave., POB 5060, Des Plaines, IL 60018, (312) 299-9311. In Japan, contact Cahners Exposition Group S.A., Hino Building 3F, 3-4-11 Uchikanda, Chiyoda-ku, Tokyo 101, Japan; tel: 03-254-6041.

February 17-19
Microcomputers in Education, New York, NY. For details, see January 18-20.

February 21-23
Office Automation Conference, Civic Center, Philadelphia, PA. More than 200 exhibitors are expected to participate in this conference. Fifty technical sessions will explore such topics as advanced office technology, current office technology and systems, and human factors and social issues. Further details are available from the American Federation of Information Processing Societies Inc., 1815 North Lynn St., Arlington, VA 22209, (703) 558-3624.

February 22-26
The Eighteenth Annual Bias-Microelettronica '83, Milan, Italy. This international exhibition is expected to attract more than 80,000 visitors. Areas of interest include active and passive components, instrumentation and equipment for component manufacturing, laboratory instrumentation, microcomputers, peripherals, and telecommunications systems. For information, contact Ente Italiano Organizzazione Mostre, Bias-Microelettronica '83, Viale Premuda 2, 20129 Milan, Italy; tel: 796.096; Telex: CONSEL 334022.

February 24-25
Computers in Construction, San Diego, CA. This seminar is designed to assist construction contractors and construction management firms in acquiring computer systems. The registration fee is $395. For further information, contact CIP Information Services Inc., 1105-F Spring St., Silver Spring, MD 20910, (301) 589-7933.

February 25-27
The Second Annual Computer Expo '83, Tupperware Convention Center, Orlando, FL. This exposition features mini- and microcomputers. The focus is on hardware, software, word processing, graphics, peripherals, supplies, services, and computer furnishings. Seminars will be held. For details, contact Tom Blayney, POB

1185, Longwood, FL 32750, (305) 339-1731.

March 1983

March 7-11

Computer-Aided Engineering and Manufacturing: Seminars and Exhibition, McKimmon Center, North Carolina State University, Raleigh. This comprehensive program is designed to update manufacturing managers, engineers, and professionals on the capabilities of computers, microprocessors, robotics, and CAD/CAM (computer-aided design/manufacturing) systems through discussions, hands-on experience, and demonstrations. Workshops will focus on computer numerical control, shop floor control and data collection, finite element methods, simulation, and software and computing systems. For further information, write to Robert Edwards, Industrial Extension Service, North Carolina State University, POB 5506, Raleigh, NC 27650.

March 8-9

ACM SIGCOMM '83—Symposium on Communications Architectures and Protocols, University of Texas, Austin. This symposium is sponsored by the Association for Computing Machinery. Address inquiries to Rebecca Hutchings, Honeywell/FSD, 7900 Westpark Dr., McLean, VA 22102, (703) 827-3982.

March 9-11

Secretary Speakout '83, Sheraton Hotel, Boston, MA. The theme for this symposium is "The Professional Secretary's New Identity in the Information Age." Speakers will address the impact of office technology through case history presentations, panels, open microphone sessions, and small discussion groups. This event is sponsored by the Professional Secretaries International Research and Educational Foundation. Full details are available from Candace M. Louis, Crown Center G-10, 2440 Pershing Rd., Kansas City, MO 64108, (816) 474-5755.

March 14-17

The Seventh Annual Federal Office Systems Expo—FOSE '83, Washington Convention Center, Washington, D C. Sixty high-level sessions will cover the development of integrated office systems in both government and industry. More than 200 companies will display the latest in office systems technology. For more information, contact Mary Beth Gouled, National Trade Productions Inc., 9418 Annapolis Rd., Lanham, MD 20706, (800) 638-8510; in Maryland, (301) 459-8383.

March 14-18

Computer Graphics Applications for Management and Productivity—CAMP '83, International Congress Center, Berlin, West Germany. This conference features tutorials, technical papers, and exhibits that reflect the practical applications and state of the art of computers and computer-graphics technology. Topics on the agenda include computer-aided design and manufacturing, sales-support graphics, and improving the

use of engineering data. A hardware and software exhibition will be held. Full particulars are available from the World Computer Graphics Association, Suite 250, 2033 M St. NW, Washington, DC 20036, (202) 775-9556.

March 16-17

Business-Expo, Houston, TX. This show features everything from computers, copiers, and telephone equipment to interior decorating office design, and financial consulting. More than 20 seminars on business technologies will be offered. Complete details are available from Business-Expo, 702 East Northland Towers, 15565 Northland Dr., Southfield, MI 48075, (313) 569-8280.

March 17-19

The Third Annual Microcomputers in Education Conference, Arizona State University, Tempe. The theme for this conference is "Forward to the 3 C's: Communicating, Calculating, and Computing." Demonstrations, workshops, and presentations will emphasize the potential of computers to revolutionize the learning process. Topics to be explored include how computers are changing the nature of: content in subject areas, teaching, and what it means to be well educated. University credit will be available. Further information can be obtained from Marilyn Sue Ford, B-47 Payne Hall, College of Education, Arizona State University, Tempe, AZ 85287, (602) 965-7363.

March 18-20

The Eighth West Coast Computer Faire, Civic Auditorium and Brooks Hall, San Francisco, CA. Attendance this year is expected to reach 40,000. More than 600 exhibitors and a wide assortment of seminars make this one of the largest annual computer shows. For more information, contact The Computer Faire, 333 Swett Rd., Woodside, CA 94602, (415) 851-7075.

March 21-24

Interface '83, Miami Beach Convention Center, Miami, FL. This conference will cover all aspects of data communications and information processing in technology, management, policy, and strategy. It is cosponsored by McGraw-Hill's *Business Week* and *Data Communications* magazines. For further details, contact The Interface Group, 160 Speen St., POB 927, Framingham, MA 01701, (800) 225-4620; in Massachusetts, (617) 879-4502.

March 21-24

Personal Microcomputer Interfacing and Scientific Instrumentation Automation, Virginia Polytechnic Institute and State University, Blacksburg, VA. This is a hands-on workshop where the participant designs and tests concepts with the actual hardware. The fee is $595. For more information, contact Dr. Linda Leffel, C. E. C., Virginia Tech, Blacksburg, VA 24061, (703) 961-4848.

March 24-25

Computers in Construction, Orlando, FL. For details, see February 24-25.

March 25

Communication Aids and Computers: A Voice for the Non-Vocal, Stokes Auditorium, Children's Hospital, Philadelphia, PA. This conference will present recent advances in technology, me-

thodology, and research as they relate to computers and speech technology. Sessions will include lectures, videotapes, and equipment demonstrations. The registration fee is $75 (if postmarked prior to March 4, 1983, the fee is $65). This conference is sponsored by the Children's Seashore House and the Division of Child Development and Rehabilitation of the Children's Hospital of Philadelphia. For further information, contact Joan Bruno, Chief Speech Pathologist, Children's Seashore House, 4100 Atlantic Ave., Atlantic City, NJ 08404, (609) 345-5191, ext. 205.

March 25-27

Fantasylair '83, Tonkawa High School, Tonkawa, OK. This annual spring gaming convention is sponsored by the Northern Oklahoma Dungeoneers. It features fantasy and war games, tournaments, a costume contest, seminars, and prizes. The admission is $3 per day; group discounts are available. For information, contact the Northern Oklahoma Dungeoneers, POB 241, Ponca City, OK 74602, (405) 762-0349.

March 28-31

National Design Engineering Show and Conference, McCormick Place, Chicago, IL. The conference is sponsored by the American Society of Mechanical Engineers' design engineering division. It will run concurrently with the National Plant Engineering and Maintenance Show and Conference. Details are available from Clapp & Poliak Inc., 708 Third Ave., New York, NY 10017, (212) 661-8410. ■

BYTE's Bits

Tandy Announces Educational Grants Program

The Radio Shack division of the Tandy Corporation has announced that $500,000 worth of TRS-80 computer equipment has been committed to a grants program designed to encourage and support the application of microcomputer technology in American educational institutions. The Tandy TRS-80 Educational Grants Program will award TRS-80 hardware, software, courseware, and related products to individuals or nonprofit educational institutions whose proposals are deemed as providing the greatest benefit to the American educational community.

An Educational Grants Review Board has been established to review proposals and to make recommendations for equipment allocations. The committee is chaired by Dr. Lee Droegemueller of the University of Arizona and includes representatives from the American Association of School Administrators, the National Council of Teachers, and distinguished educators.

A packet of information containing a cover letter, TRS-80 brochure, catalog, submission information, and a proposal cover sheet is available from the Tandy TRS-80 Educational Grants Program, Radio Shack Education Division, 400 Tandy Atrium, Fort Worth, TX 76102. ■

Software Received

Apple

The Arcade Machine, a program that helps you create your own arcade games. Games may have animated full-color graphics, sound effects, and automatic scoring and are designed by means of menu selections. For the Apple II and II Plus; floppy disk, $59.95. Broderbund Software Inc., Entertainment Software Division, 1938 Fourth St., San Rafael, CA 94901.

Discover BASIC, a guide to problem solving with Applesoft BASIC. This package includes a teacher's guide and a student workbook for learning about BASIC. Demonstration programs and sample solutions are included. For the Apple II Plus; floppy disk, $74.95. Sterling Swift Publishing Co., 1600 Fortview Rd., Austin, TX 78704.

Earl's Word Power, an educational program that helps students develop a better vocabulary by introducing new words and then using Shakespearean plays to test word retention. For the Apple II; floppy disk, $29.95. George Earl, 1302 South General McMullen, San Antonio, TX 78237.

Earth Defender, an arcade-type game. You must save the Earth by manning your laser-equipped spaceship and destroying all invading aliens, nuclear missiles, and asteroids. For the Apple II and II Plus; floppy disk, $29.95. New Vision, Suite 15, 5150 Peachtree Industrial Blvd., Chamblee, GA 30341.

Editor/Assembler, an editor and assembler package. This menu-driven system features full-screen list and edit capabilities, system status display, and up to 27K bytes for source code. For the Apple II and II Plus; floppy disk, $89. Custom Micro Systems Ltd., 16921 108 St., Edmonton, Alberta, T5X 3B2, Canada.

Free Fall, an arcade-type game. As your player falls through a maze, you must maneuver it around falling debris, which consists of girders, bio-bops, and gunners. This game has three levels of difficulty. For the Apple II; floppy disk, $29.95. Sirius Software Inc., 10364 Rockingham Dr., Sacramento, CA 95827.

The Integer Fix, a system that converts disks containing Integer BASIC so that they may be run on an Apple II Plus. Converted programs can operate with both Applesoft and Integer BASIC. For the Apple II Plus; floppy disk, $20. Barrington Educational Computer, POB 863, Barrington, IL 60010.

Inventory Manager, an inventory-control program that can maintain records on up to 1200 items on a single-disk system or 2700 items on two disks. Items may have as many as 13 categories. For the Apple II and II Plus; floppy disk, $149.95. Synergistic Software, Suite 201, 830 North Riverside Dr., Renton, WA 98055.

Kamikaze, an arcade-type game. You are in control of a coastal defense ship that's under attack by successive waves of kamikaze fighters, low- and high-level bombers, and mines. For the Apple II; floppy disk, $34.95. Hayden Software Co., 600 Suffolk St., Lowell, MA 01853.

The List Handler, a database-management program. This program can create and maintain a file of up to 3000 records, with 255 fields each. It allows editing and can print lists and mailing labels. For the Apple II and II Plus; floppy disk, $89.95. Silicon Valley Systems Inc., Suite 4, 1625 El Camino Real, Belmont, CA 94002.

Math Strategy, an educational program that teaches basic mathematics skills through the use of graphics and techniques based on the latest research in learning theory. For the Apple II; floppy disk, $45. Apple Computer Inc., 20525 Mariani Ave., Cupertino, CA 95014.

Micro Cookbook, a program that will save your recipes, select a recipe based on ingredients on-hand or by category, and adjust a recipe for a number of servings. For the Apple II Plus; floppy disk, $30. Virtual Combinatics, POB 755, Rockport, MA 01966.

Molec, a program that allows you to view three-dimensional models of molecules. The package is supplied with 13 organic molecules, or you can design your own using up to 64 atoms per molecule. For the Apple II; floppy disk, $150. Cambridge Development Laboratory, 36 Pleasant St., Watertown, MA 02172.

Money Munchers, an arcade-type game. Enter the maze to grab all the money you can, but look out for the money munchers who will eat your booty. You must also evade spiders and snakes. For the Apple II; floppy disk, $29.95. Datamost, 9748 Cozycroft Ave., Chatsworth, CA 91311.

Psychological Diary, a program that will assist you in developing a better understanding of your inner self. This program provides a personal diary and such tests as personality, relationship, and sentence completion. For the Apple II; floppy disk, $39.95. Psychological Systems, 1519 Burlington Rd., Cleveland Heights, OH 44118.

Seafox, an arcade-type game. Your mission is to pilot your submarine and destroy the convoy of enemy ships and their escorts. You must dodge depth charges, mines, and torpedoes. For the Apple II and II Plus; floppy disk, $29.95. Broderbund Software (see address above).

Shapes in Color, a system that lets you design high-resolution animation and graphics. A variety of color shapes and character fonts can be constructed and saved. For the Apple II; floppy disk, $49.95. Hayden Software Co. (see address above).

Shuttle Intercept, an arcade-type game. You must retrieve the friendly satellites bearing vital data while avoiding or shooting the enemy satellites, missiles, saucers, and meteors. For the Apple II; floppy disk, $34.95. Hayden Software Co. (see address above).

Singles' Night at Molly's, a package containing two solitaire card games, Royal Flush and Sly Fox. These programs feature high-resolution graphics and automatic score keeping. For the Apple II and II Plus; floppy disk, $29.95. Soft Images, 200 Route 17, Mahwah, NJ 07430.

Speed Reader, a five-part program designed to help improve your reading skills. The exercises and lessons will teach you to increase your reading speed and perception. For the Apple II; floppy disk, $70. Apple Computer Inc. (see address above).

Spelling Strategy, an educational program that helps you to spell better by using a variety of techniques to visualize and remember the correct spelling of words. For the Apple II; floppy disk, $45. Apple Computer Inc.(see address above).

Starcross, an adventure-type game. Your mission was to secure a black-hole power source, but now you've come across gigantic alien spacecraft. You must explore the craft and discover its secrets. For the Apple II; floppy disk,

$39.95. Infocom Inc., 55 Wheeler St., Cambridge, MA 02138.

Star Maze, an arcade-type game. Your mission is to find the nine power jewels in each level of the maze and return them to your mother ship. The maze has 16 levels. For the Apple II; floppy disk, $34.95. Sir-Tech Software Inc., 6 Main St., Ogdensburg, NY 13669.

SuperPILOT, a new implementation of the PILOT language. This system features improved graphics control, flexibility to use video tape and videodisc players, and turtle graphics. For the Apple II; floppy disk, $200. Apple Computer Inc. (see address above).

Type Attack, an educational game. The objective of this game is to learn to touch-type by seeing characters on the screen and pressing the corresponding keys on the keyboard. For the Apple II; floppy disk, $39.95. Sirius Software Inc. (see address above).

Warp Destroyer, an arcade-type game. After traveling through hyperspace, you will be faced with mines, fighters, and probes. You must shoot these and go on to the Zalbian bases before you can return. For the Apple II and II Plus; floppy disk, $29.95. Piccadilly Software Inc., 89 Summit Ave., Summit, NJ 07901.

Wayout, an arcade-type game. Working with the cardboard compass and glasses provided in the package, find your way out of the maze by using the mapmaker and watching the fireflies. For the Apple II and II Plus; floppy disk, $39.95. Sirius Software Inc. (see address above).

Word Weaver III, a word-processing system. This system uses all standard word-processing features, including 80-column display, menu-driven functions, and global editing commands. For the Apple III; floppy disk, $99.95. Synergistic Software (see address above).

You're the Doctor, a simulation-type game. You become a doctor examining patients, trying to diagnose and prescribe treatment. This simulation game includes high-resolution graphics and sound. For the Apple II; floppy disk, $17.95. Simulations Software, POB 608, Station U, Toronto, Ontario, M8Z 5Y9, Canada.

Zork III: The Dungeon Master, an adventure-type game. The final episode in the Zork trilogy takes you to a confrontation with the Dungeon Master himself. This game responds to plain English commands. For the Apple II; floppy disk, $39.95. Infocom Inc. (see address above).

Atari

Claim Jumper, a two-player arcade-type game. The object is to get all the gold you can, trade it for money, and get your money to the bank. Beware of claim jumpers, snakes, and killer tumbleweeds. For the Atari 400/800; floppy disk, $34.95. Synapse Software, Suite I, 5327 Jacuzzi St., Richmond, CA 94804.

Escape from Vulcan's Isle, a graphics adventure-type game. You're shipwrecked on a desert island. You must explore and discover a way off the island before the volcano erupts. On your way, you collect magic treasures—but avoid the monsters. For the Atari 400/800; floppy disk, $29.95. Epyx/Automated Simulations, 1043 Kiel Court, Sunnyvale, CA 94086.

King Arthur's Heir, a graphics adventure-type game. You must prove yourself worthy to hold the crown of Camelot. Your quest is to find the Scroll of Truth, hidden by Merlin. For the Atari 400/800; floppy disk, $29.95. Epyx/Automated Simulations (see address above).

Marathon, an educational game. The object in this math quiz is to get your runner across the screen first by correctly answering the problems. The game has four levels of play and is designed for ages 8 to 16. For the Atari 400/800; floppy disk, $19.95. Educational Software Inc., 4565 Cherryvale Ave., Soquel, CA 95073.

Protector II, an arcade-type game. You must rescue 18 people from alien attack and deposit them safely on the other side of a volcano. This game features improved play and action. For the Atari 400/800; floppy disk, $34.95. Synapse Software (see address above).

Space Games, a games package that includes adventure- and arcade-type games. You must find your way out of the maze and shoot the aliens to save your home in outer space. For the Atari 400/800; floppy disk, $24.95. Educational Software Inc. (see address above).

Valley of the Kings, a graphics adventure-type game. You are in a mountainous region of Egypt and you must locate objects and passages to survive the three levels of the game. For the Atari 400/800; floppy disk, $29.95. Dynacomp Inc., 1427 Monroe Ave., Rochester, NY 14618.

CP/M

Cardbox, a simple database-management system. Entries to this database are treated as electronic index cards. You can select input, report, and display formats and retrieve data using keywords. For CP/M-based systems; floppy disk, $245. Caxton Software Publishing Co., 10-14 Bedford St., Covent Garden, London, WC2E 9HE, England.

MCDisplay, a terminal interface program. With this program, complete terminal displays can be defined in advance, which simplifies text and data entries and enhances prompts and messages. Display layout sheets are included. For CP/M-based systems; floppy disk, $175. Mastercomputing Inc., POB 17442, Greenville, SC 29606.

Medent, an accounts-receivable system designed for medical and dental offices. This system features record-access by number or name and automatic statements with aging. For CP/M-based systems; floppy disk, $1900. Community Computer Service Inc., POB E, Auburn, NY 13021.

Members Program, a mailing-list management program. Designed for maintaining member lists of organizations, this program can create, modify, and output alphabetically sorted lists or mailing labels. For CP/M-based systems; floppy disk, $75. Datamasters, Unit 10, 12700 Northeast 124th St., Kirkland, WA 98033.

Microsoft Multiplan, an electronic spreadsheet system that features an on-line reference guide, alphanumeric sorting, up to eight display windows, use of Visicalc files, and variable-width columns. For CP/M-based systems; floppy disk, $275. Microsoft Corp., C-97200, 10700 Northrup Way, Bellevue, WA 98004.

Oubliette, an adventure-type game similar to Dungeons and Dragons. You must seek the gold hidden in the dungeon beneath the castle. You can define your player's characteristics. For CP/M-based systems; floppy disk, $39.95. Computer Management Service, 501 Jackson, Charleston, IL 61920.

SCP/80, a set of utility programs to enhance CP/M. These programs facilitate data movement or modification and display status of files, memory, and devices. For CP/M-based systems;

floppy disk, $100. A. B. Hutchison Engineering, 1354 Southwest 12th Ave., Pompano Beach, FL 33060.

Yousable Youtilities, a set of 13 Unix-like utility programs. Standard features include redirecting console output to a disk file, comparing files, simple copy and backup procedures, and concatenating multiple files. For CP/M-based systems; floppy disk, $95. Software Island Inc., Suite 109, 5858 Mt. Alifan Dr., San Diego, CA 92111.

Commodore

Aggressor, an arcade-type game. Your mission as a Marauder pilot is to protect the settarium ore dump on New Earth from attacking Zaurian spacecraft. You are armed with lasers and bombs. For the VIC-20; cartridge, $39.95. Human Engineered Software, 71 Park Lane, Brisbane, CA 94005.

The Count, an adventure-type game. You wake up somewhere in Transylvania and you must escape with your life. The game is adapted from the Scott Adams original. For the VIC-20; cartridge, $39.95. Commodore International Ltd., The Meadows, 487 Devon Park Dr., Wayne, PA 19087.

Dam Bomber, an arcade-type game. Pilot your plane and avoid the enemy fire if you can. You must carefully drop your bombs to destroy the dam and release the flood waters. For the VIC-20; cassette, $15.95. Human Engineered Software (see address above).

Gorf, a set of four arcade-type games: Astro Battles, Laser Attack, Space Warp, and Flagship. For the VIC-20; cartridge, $39.95. Commodore International Ltd. (see address above).

Hes Mon, a 6502 machine-language monitor featuring more than 25 commands for testing memory, dumping a screen display to a printer, or disassembling machine code into assembly language. For the VIC-20; cartridge, $39.95. Human Engineered Software (see address above).

Hes Writer, a word-processing program that incorporates most standard features such as full-screen editing, right and left justification, move and delete text, and use of headers and page numbering. For the VIC-20; cartridge, $39.95. Human Engineered Software (see address above).

Investment Allocation, a program that accepts, processes, stores, and displays information concerning your investment portfolio. Up to 50 investments can be entered and analyzed. For the VIC-20; cassette, $8.98. Martin Glasser, 121-B Birch Circle, Elgin AFB, FL 32542.

Maze of Mikor, an arcade-type game that challenges you to steal the Warlock's gold as you try to avoid a demon. For the VIC-20; cassette, $17.95. Human Engineered Software (see address above).

Mole Attack, an arcade-type game. You must try to keep those nasty moles underground by bopping them on the head. Bop as many as you can before time runs out. For the VIC-20; cartridge, $29.95. Commodore International Ltd. (see address above).

Omega Race, an arcade-type game. In the middle of a space arena, you must fight three types of deadly android warrior ships and avoid two kinds of mines. For the VIC-20; cartridge, $39.95. Commodore International Ltd. (see address above).

Pak Bomber, a pak monster drops bombs that you must catch or an explosive chain reaction will be set off. For the VIC-20; cassette, $15.95. Human Engineered Software (see address above).

Renaissance, a simulation game in which the VIC becomes your opponent in an Othello-type game. The computer will give you hints and display a recommended best move. For one player. For the VIC-20; cartridge, $49.95. United Microware Industries Inc., 3503-C Temple Ave., Pomona, CA 91768.

Sargon II Chess, a simulation game. Sargon II is a sophisticated computer chess program that has seven levels of play. You can set up the pieces for practice or end games. For the VIC-20; cartridge, $39.95. Commodore International Ltd. (see address above).

Skier, an arcade-type game. You become a skier in a downhill race. Avoid the flags and obstacles as you hurtle down the slopes. This game features three levels of play. For the VIC-20; cassette, $17.95. Human Engineered Software (see address above).

Spiders of Mars, an arcade-type game. As a Martian Space Fly, you must defend your planet against the Spiders of Mars and their allies. You possess neutron bombs, but your enemies are numerous and deadly. For the VIC-20; cartridge, $49.95. United Microware Industries Inc. (see address above).

Tank Trap, an arcade-type game. You must build walls to protect people from the crazed tank driver. This game features four levels of difficulty. For the VIC-20; cassette, $17.95. Human Engineered Software (see address above).

Tank Wars, an arcade-type game. Match your wits against the computer as you drive your tank around obstacles and mines. For the VIC-20; cassette, $17.95. Human Engineered Software (see address above).

Turtle Graphics, an introduction to computer programming. This program provides an easy-to-learn computer language that illustrates the basic concepts of computer programming. It features colorful graphics. For the VIC-20; cartridge, $39.95. Human Engineered Software (see address above).

VIC FORTH, an implementation of the FORTH language. An interactive computer language, FORTH is faster than BASIC and very memory efficient. This package features sound, graphics, and a screen editor. For the VIC-20; cartridge, $59.95. Human Engineered Software (see address above).

Victrek and **Victrek 8K,** a set of two Star Trek-type games. You must scan galactic maps and maneuver through starbases as you battle the Klingons for control of the galaxy. For the VIC-20; cassette, $17.95. Human Engineered Software (see address above).

IBM Personal Computer

Computer Chef, a computerized cookbook. This program lets you enter and save recipes, find recipes with selected ingredients, and adjust recipes for the number of servings. For the IBM Personal Computer; floppy disk, $49.95. Norell Data Systems, 3400 Wilshire Blvd., POB 70127, Los Angeles, CA 90010.

Meteor-Math, an educational game. Students can learn basic mathematics by answering problems. This program has two modes and features sound, color, and graphics. For the IBM Personal Computer; floppy disk, $39.95. Brauer Computer Support, POB 86634, San Diego, CA 92138.

Pig Pen, an arcade-type game. You must find your way out of the four levels of the maze and avoid the fierce wild pigs. Your only salvation is to find the potent pig pills. For the IBM Personal Computer; floppy disk,

$29.95. Datamost, 9748 Cozycroft Ave., Chatsworth, CA 91311.

Real Estate Analyzer, an investment analysis program. It allows you to make accurate investment decisions and determine the rate of return on real-estate purchases. Reports show cash flow and profits upon sale. For the IBM Personal Computer; floppy disk, $250. Howard Software Services, Suite 310, 8008 Girard Ave., La Jolla, CA 92037.

System-Backup, a utility program that allows you to make a backup copy of any IBM PC disk, regardless of the sector size and the track format used. This program automatically formats disks. For the IBM Personal Computer; floppy disk, $50. Norell Data Systems (see address above).

Videolink 88, a telecommunications package. This program changes the IBM into an intelligent terminal. Specifications may be user-defined, and the program supports the Hayes Smartmodem. For the IBM Personal Computer; floppy disk, $59.95. Windmill Software Inc., 1058 Joan Dr., Burlington, Ontario, L7T 3H2, Canada.

TRS-80

Air Traffic Control, a real-time simulation game that challenges you to direct aircraft to a safe landing by using radar and flight computer displays. For the TRS-80 Color Computer; cassette, $8.95. Geographics Software, 95 Eastbury Hill Rd., Glastonbury, CT 06033.

The Arranger, a computer disk library program. You can create a master disk that contains a record of every file on every disk you own. You can edit entries and locate individual files and their disk numbers. For the TRS-80 Models I and III; floppy disk, $29.95. Triple-D Software, POB 642, Layton, UT 84041.

Brevi-T, a NEWDOS/80 version 2.0 utility program. You can create abbreviations for commonly used or difficult to remember DOS or BASIC commands. Command abbreviations may be added or changed at anytime. For the TRS-80 Models I and III; floppy disk, $19.95. Softrends Inc., 26111 Brush Ave., Euclid, OH 44132.

Colored Fonts, a character-generator utility package with which you can create your own character sets for screen display. Four predefined character sets and an Epson MX-80 screen-dump utility are standard. Available in 16K- and 32K-byte formats. For the TRS-80 Color Computer; floppy disk and casstte, $29.95 and $24.95, respectively. Renaissance Game Designs, POB 1232, Montclair, NJ 07042.

Color-FORTH, an implementation of the FORTH language for the Color Computer. This version has words for graphics, sound, fast math, and an auto repeat and control key. A ROM version is available. For the TRS-80 Color Computer; cassette, $58.95. Hoyt Stearns Electronics, 4131 East Cannon Dr., Phoenix, AZ 85028.

Lasertank Duel, a two-player, arcade-type game. You and your opponent control tanks maneuvering along city streets. The object of the game is to score points by hitting your opponent with laser beams. For the TRS-80 Color Computer; floppy disk and cassette, $19.95 and $15.95, respectively. Renaissance Game Designs (see address above).

Stopper, a BASIC programming utility. You can set breakpoints at specific lines within a program, show the current value of a variable, or single-step a program through a range of lines. For the TRS-80 Models I and III; floppy disk or cassette, $20. The Alternate Source, 704 North Pennsylvania, Lansing, MI 48906.

Strike Force, an arcade-type game. Your task is to defend your five cities from alien attack and destroy the aliens' base. You are armed with star shells and missiles. For the TRS-80 Model I and III; floppy disk and cassette, $19.95 and $15.95, respectively. Melbourne House Software Inc., 333 East 46 St., New York, NY 10017.

Other Computers

Home Financial Package, mortgage analysis, IRA Account Planner, and Bond Investment programs. For the Sinclair ZX81; BASIC listing, $1. Florida Creations, Department P, POB 16422, Jacksonville, FL 32245.

Nos BASICode, a utility program that enables the exchange of BASIC programs between different brands of microcomputers. Most popular brands are supported, with some modification required. For the BASIC language system; cassette, 30 Dutch guilders. BASICode, Administratie Algemen Secretariat, Nos, POB 10, 1200 JB Hilversum, The Netherlands.

TV Sketch, a program that allows you to create colorful video paintings. For the TI-99/4; cassette, $9. Glo-Data, POB 374, Stony Point, NY 10980.

Z193D.ABS, a three-dimensional graphics program. It allows you to create, manipulate, and save three-dimensional images. This program features hidden line and hidden surface removal. For the Heath H-19/H-89; floppy disk, $25. Colorworks, 5337 East Bellevue, Tucson, AZ 85712.■

This is a list of software packages that have been received by BYTE Publications during the past month. The list is correct to the best of our knowledge, but it is not meant to be a full description of the product or the forms in which the product is available. In particular, some packages may be sold for several machines or in both cassette and floppy-disk format; the product listed here is the version received by BYTE Publications.

This is an all-inclusive list that makes no comment on the quality or usefulness of the software listed. We regret that we cannot review every software package we receive. Instead, this list is meant to be a monthly acknowledgment of these packages and the companies that sent them. All software received is considered to be on loan to BYTE and is returned to the manufacturer after a set period of time. Companies sending software packages should be sure to include the list price of the packages and (where appropriate) the alternate forms in which they are available.

BYTE's Bits

Call for Papers

The International Conference Committee for the Eleventh Automatic Testing and Test Instrumentation Conference is seeking papers on the subject of computer-aided design, measurement, and testing (CADMAT). The conference will be held at the Metropole Convention Centre, in Brighton, England, from December 13 to 15, 1983. Submit a 250-word synopsis to the CADMAT Conference Secretary, Network Exhibitions Ltd., Printers Mews, Market Hill, Buckingham MK18 1JX, England; telephone (02802) 5226.■

Books Received

Apple BASIC, Richard Haskell. Englewood Cliffs, NJ: Prentice-Hall, 1982; 183 pages, 50.5 by 66 cm, softcover, ISBN 0-13-039099-2, $12.95.

Applications and Design with Analog Integrated Circuits, J. Michael Jacob. Reston, VA: Reston Publishing, 1982; 498 pages, 45 by 57 cm, hardcover, ISBN 0-8359-0245-5, $30.95.

Artificial Reality, Myron W. Krueger. Reading, MA: Addison-Wesley, 1983; 312 pages, 37 by 56 cm, softcover, ISBN 0-201-04765-9, $10.95.

Assembler Language for Application Programming, Don H. Stabley. Princeton, NJ: Petrocelli Books, 1982; 677 pages, 46 by 61.5 cm, hardcover, ISBN 0-89433-176-0, $35.

COBOL, A Comprehensive Treatment, Thomas L. Naps and Bhagat Singh. Reston, VA: Reston Publishing, 1982; 498 pages, 42.5 by 56.5 cm, softcover, ISBN 0-8359-0830-5, $17.95.

Comparative Studies in Software Acquisition, Steven Glaseman. Lexington, MA: Lexington Books, 1982; 131 pages, 16.4 by 23.3 cm, hardcover, ISBN 0-669-05422-4, $18.95.

Computing: An Introduction to Structured Problem Solving Using Pascal, V. A. Dyck, J. D. Lawson, J. A. Smith, and R. J. Beach. Reston, VA: Reston Publishing, 1982; 625 pages, 44.5 by 57.5 cm, hardcover, ISBN 0-8359-0902-6, $21.95.

Concepts of ARC Local Networking. San Antonio, TX: Datapoint Corp. (9725 Datapoint Dr.), 1982; 70 pages, 51 by 66 cm, softcover, ISBN-none, Document Number 50694, $4.

Digital, Analog, and Data Communication, William Sinnema. Reston, VA: Reston Publishing, 1982; 433 pages, 44 by 57.5 cm, hardcover, ISBN 0-8359-1301-5, $29.95.

Electronic Manufacturing, Sheldon I. Kohen and Michael Rose. Reston, VA: Reston Publishing, 1982; 308 pages, 43.5 by 57.5 cm, hardcover, ISBN 0-8359-1642-1, $25.95.

Experiments for Electrical Circuit Analysis with BASIC Programming, Theodore F. Bogart Jr. Chicago, IL: Science Research Associates, 1982; 288 pages, 51 by 65.5 cm, softcover, ISBN 0-574-21565-4, $11.96.

How to Write an Apple Program, Ed Faulk. Chatsworth, CA: Datamost Inc. (9748 Cozycroft Ave.), 1982; 220 pages, 32 by 49.5 cm, softcover, ISBN 0-8359-2992-2, $14.95.

How to Write an IBM-PC Program, Ed Faulk. Chatsworth, CA: Datamost Inc. (9748 Cozycroft Ave.), 1982; 427 pages, 32 by 49.5 cm, softcover, ISBN 0-8359-2991-4, $14.95.

The Intelligent Microcomputer, Roy W. Goody. Chicago, IL: Science Research Associates, 1982; 344 pages, 52 by 67 cm, hardcover, ISBN 0-574-21560-3, $19.16.

Interface Projects for the TRS-80 Mod III, Richard C. Hallgren. Englewood Cliffs, NJ: Prentice-Hall, 1982; 152 pages, 41 by 55 cm, softcover, ISBN 0-13-469429-5, $12.95.

An Introduction to Process Control and Digital Minicomputers, Peter L. Ginn. Houston, TX: Gulf Publishing, 1982; 291 pages, 16.4 by 23.4 cm, hardcover, ISBN 0-87201-180-1, $26.95.

Pascal Programming Structures for Motorola Microprocessors, George W. Cherry. Reston, VA: Reston Publishing, 1982; 359 pages, 41.5 by 56 cm, softcover, ISBN 0-8359-5465-X, $15.95.

Pascal Text and Reference with Waterloo Pascal and Pascal VS, John B. Moore. Reston, VA: Reston Publishing, 1982; 398 pages, 42.5 by 55 cm, softcover, ISBN 0-8359-5457-8, $16.95.

PET/CBM and the IEEE 488 Bus (GPIB), 2nd edition, Eugene Fisher and C. W. Jenson. Berkeley, CA: Osborne/McGraw-Hill, 1982; 319 pages, 38.5 by 55.5 cm, softcover, ISBN 0-931988-78-0, $15.99.

Practical BASIC Programs, IBM Personal Computer Edition, Lon Poole, ed. Berkeley, CA: Osborne/McGraw-Hill, 1982; 162 pages, 50.5 by 66 cm, softcover, ISBN 0-931988-80-2, $15.99.

Principles of EDP Management, Alexander Gaydasch. Reston, VA: Reston Publishing, 1982; 336 pages, 44 by 58 cm, hardcover, ISBN 0-8359-5604-0, $19.95.

Profitable Small Business Computing, Frank Greenwood. Boston, MA: Little, Brown & Co., 1982; 168 pages, 35 by 54 cm, softcover, ISBN 0-316-327123-3, $9.95.

Residential Electrical Wiring, Harry J. Edwards Jr. Reston, VA: Reston Publishing, 1982; 224 pages, 44 by 59 cm, hardcover, ISBN 0-8359-6652-6, $17.95.

Software Engineering, Analysis & Verification, T. G. Lewis. Reston, VA: Reston Publishing, 1982; 470 pages, 45 by 57 cm, hardcover, ISBN 0-8359-7023-X, $22.95.

Structured COBOL Report Writer: A Programmer's Productivity Tool, David Schechter and George W. Yvkoff. Reston, VA: Reston Publishing, 1982; 300 pages, 43.5 by 57.5 cm, hardcover, ISBN 0-8359-7097-3, $24.95.

Structured Programming Using PL/I, 2nd edition, J. N. P. Hume and R. C. Holt. Reston, VA: Reston Publishing, 1982; 400 pages, 41 by 55.5 cm, softcover, ISBN 0-8359-7131-7, $16.95.

Techniques for Creating Golden Delicious Games for the Apple Computer, Howard M. Franklin, Joanne Koltnow, and Leroy Finkel. Somerset, NJ: John Wiley & Sons, 1982; 150 pages, 40.5 by 60 cm, softcover, ISBN 0-471-09083-2, $12.95.

The Visicalc Book: Apple Edition, Donald H. Beil. Reston, VA: Reston Publishing, 1982; 301 pages, 45 by 57 cm, hardcover, ISBN 0-8359-8398-6, $22.95.

The Visicalc Book: Atari Edition, Donald H. Beil. Reston, VA: Reston Publishing, 1982; 298 pages, 45 by 57 cm, hardcover, ISBN 0-8359-8394-3, $21.95. ■

This is a list of books received at BYTE Publications during this past month. Although the list is not meant to be exhaustive, its purpose is to acquaint BYTE readers with recently published titles in computer science and related fields. We regret that we cannot review or comment on all the books we receive; instead, this list is meant to be a monthly acknowledgment of these books and the publishers who sent them.

Ask BYTE

Conducted by Steve Ciarcia

An Address in Every Port

Dear Steve,

After owning a Radio Shack TRS-80 Model I for three and a half years, I purchased a Model III. I was surprised to find that the printer can be addressed at I/O ports 248, 249, 250, and 251. When programming the Model I, it was always my practice to poke a formfeed character to location 37E8 hexadecimal in order to circumvent the Radio Shack printer driver, which converts formfeeds into an appropriate number of linefeeds. In the Model III, that location is assigned to ROM (read-only memory), although performing a PEEK of that address will provide the printer-status information, as in the Model I. Which of the four ports is the correct address to use for the printer, or does it matter (and why)?

Kerry A. Wilson
Owensboro, KY

By referring to the schematic diagram of the Model III, I have found that the printer port is enabled when address lines A3 through A7 are high and when A2 is low. Because lines A0 and A1 are not used, they don't affect the decoding process. Any of the addresses 248 through 251 will satisfy the decoding requirements and enable the printer port. . . . **Steve**

Other Keyboards for the ZX80

Dear Steve,

I've just read Wayne J. Cosshall's article entitled "New Keyboard for the ZX80" (March 1982 BYTE, page 256). I have recently decided to purchase a Sinclair ZX81 microcomputer kit, but have been somewhat hesitant because of its small keyboard. Naturally, I was extremely enthusiastic upon seeing this article.

I happen to have a Jelco Type PR-5701 keyboard that looks quite similar to the one in Mr. Cosshall's article. I would like to wire this into my ZX81 kit, but I'm wondering whether the printed-circuit boards for the ZX80 and the ZX81 are all that similar? With the 8K-byte ROM (read-only memory) in the ZX81, some 40 new functions accessible from the new keyboard have been added. My question is can I still go ahead and wire a full 57-key keyboard in my ZX81, using the directions in Mr. Cosshall's article? If not, how can I wire it into the ZX81? My Jelco keyboard is the same one used in the Radio Shack TRS-80 series, and I also have a keyboard that is identical to one on Radio Shack's Color Computer. Which one would be better to use for my ZX81 application? I appreciate your time and consideration on this matter.

Robert Y. Million
Cupertino, CA

The printed-circuit board for the Sinclair ZX81 is different from the ZX80, but the full-sized keyboard can still be installed as described in Wayne Cosshall's article. If you buy the ZX81 kit, you will have the schematic diagram and you will be able to easily locate the connections for A8 through A15. D0 through D4 are located on resistor package RP3 and are wired as follows:

D0 = KBD1
D1 = KBD0
D2 = KBD2
D3 = KBD3
D4 = KBD4

You might have some confusion in using the new keyboard with all of the extra functions that the ZX81 now incorporates. Some sort of labeling for the keyboard should help. Either of the keyboards you mentioned should be satisfactory for your ZX81 application. . . . **Steve**

Uninterruptible Power Supplies Problem Solved

The following letter presents an innovative solution to the problem of building uninterruptible power supplies—a topic of perennial interest to many of this column's readers. . . . **Steve**

Dear Steve,

On moving to Indonesia last year, I was faced with a problem similar to the one Albert C. Pollard encountered (see "Power Backup," February 1982 BYTE, page 366). I wanted to use my Radio Shack TRS-80 Model I, but the commercial power is unreliable: the voltage fluctuates and can be out for quite awhile. In addition, the power is supplied at 220 V (volts) at 50 Hz.

I sought advice from the salespeople at the store where I bought the computer and from a Radio Shack technical representative in Fort Worth, Texas, but they had no help to offer. Then, a distributor of Tripp Lite inverters suggested I try one of its units in combination with an automobile battery. Tripp Manufacturing Company of Chicago, Illinois, makes power inverters that people often use to supply 120 V at 60 Hz to television sets in their campers where normally only 12 V DC is available.

I was a little dubious at first, knowing that the inverter produced a square wave (rather than the sine wave supplied by commercial power companies), but the arrangement worked flawlessly when I tried it. I now have a UPS (uninterruptible power supply) to run my Model I with its two 5¼-inch disk drives and Anadex DP-8000 printer. My Tripp Lite PV-350 inverter can supply about 250 watts (W) to the computer system when connected to my 12-V Delco N-120 TS Freedom battery. The battery is kept charged by a 12-V, 6-amp charger built to work with the local 220-V power. Total cost was approximately $200.

With this system, my computer can run for hours—even during prolonged blackouts. It isolates the computer system from the frequent power surges that are common here, and it has solved the frequency mismatch as well. I have been using the power supply for nine months and have not lost a bit of data due to power problems.

The cost is less than a comparable system I have seen advertised. Also, the battery size can be reduced, depending on how much you want to spend and how long a blackout you anticipate. The only drawbacks seem to be a slightly increased audible hum from the computer's transformer and a slight horizontal disruption of the video-screen's display that travels up the screen about 40 cycles per minute. Neither are particularly distracting; I have tried several of the other Tripp Lite inverters (even the much more expensive PV-500 frequency-controlled unit) without any change in the video distortion, which appears to be inherent in the design of the

inverter (perhaps related to the fact that it produces a square wave).

I have no idea whether a similar system would work for other computers, but it is a simple solution other TRS-80 owners might want to try.

Richard T. Nicholls, MD
Indonesia

RS366 Specification Explained

Dear Steve,

In a recent advertisement, a modem was described as being "RS366 and RS-232C" compatible. I know the RS-232C, but what is an RS366?

Thanks for the many fine articles you have written for BYTE.

Michael F. Smith
Athens, TN

RS366 is a specification describing the interface between DTE (data terminal equipment) and ACU (automatic calling units) for data communications. The most common system uses the Bell-type 801A ACU to generate pulses similar to a rotary-dial telephone. The Bell-type 801C generates Touch-Tone signals.

Each ACU requires an RS366 adapter, an RS-232C interface, and a modem connected to a single phone line. The RS366 interface uses the same 25-pin connector as the RS-232C interface but has different pin assignments and functions. . . . **Steve**

Advice for Potential Homebrewers

Dear Steve,

I am just becoming a computer fan, but I don't know which way to go to get started. My total experience with computers is on the college level; I have a semester of BASIC Plus using a DEC (Digital Equipment Corporation) PDP 11/70.

I would like some advice on acquiring equipment. I have been considering the Sinclair ZX81 with the 16K-byte memory package, but even in the kit form, it costs more than $200. For a little more money, I could get Commodore's VIC-20, but I would rather build a computer myself, because that way over a period of time I feel that I could get more computer for the money.

Actually, what I am looking for is an instrument that can be assembled by someone with kit-building experience and that would be able to interface with a TV as a video display. It would have to be able to handle limited files in cassette form. I am a Motor Vehicle Department investigator and want to keep some of my work records and cases on it. (Tape is easier to store than reams of paper.) I would like the instrument to have expandable memory, because it will be for general use. In addition to my work, I would like to be able to run games on it.

T. J. Willis
Waterbury Center, VT

With the variety of computers that are now on the market, it is becoming difficult to build a computer with more features for less than you can buy one. Plus, if you have little technical expertise or lack a good dual-trace oscilloscope, troubleshooting a homebrew computer can be a nightmare. One approach to take would be to buy assembled and tested boards that plug into a motherboard for a standard bus, such as S-100, SS-50, KIM, and Z8, to name a few, and expand as your interests and finances warrant.

Determine how much you wish to spend for an entry-level system, try to establish what you ultimately will do with your computer, and shop accordingly. A local computer store will give you a sales pitch on the brands

that they sell and will explain features that you may not be aware of. Listen to them and ask questions. That will give you a good idea of what is available.

One thing to consider with a home-built computer is the limited software available, especially if it is a cassette-based system. If you are a user rather than a programmer, this will be very important to you. . . . **Steve**

Tie Chips for More Memory

Dear Steve,

I have a problem I'm sure a lot of people share. I have a TRS-80 Color Computer and would like to expand the memory to 32K bytes. When I installed the eight doubled-up (piggyback) 4116s, the PRINT MEM function still responded as if there were only 16K bytes. I have the old revision D board, and it has no jumper for 32K. I would appreciate your help in this matter, because I have a limited budget and spent quite a bit on the chips.

Frank R. Durr II
Tampa, FL

Expanding the Radio Shack Color Computer to 32K is relatively simple. Your scheme of adding eight additional 4116-type memory chips in parallel with the present chips is correct except that pin 4 of the added chips must be separated. Tie pin 4 on all of the added chips together and connect them to pin 35 of the MC6883 (U10). This will provide the required chip select for the second bank and will give you the memory expansion that you desire.

An excellent article on the operation and programming of the Color Computer can be found in the March 1981 BYTE. (See "What's Inside Radio Shack's Color Computer?" by Tim Ahrens, Jack Browne, and Hunter Scales, page 90.) It is recommended reading for anyone with a Color Computer. . . . **Steve**

TVs for Monitors

Dear Steve,

Could you please tell me if there is any information on using a TV (without a radio-frequency modulator) as a monitor? I have some old black-and-white units that I would like to use. Would I feed the video via a field-effect transistor to get the video-drive level? Thank you.

Murray Gilbert
West Hempstead, NY

Converting a television to a video monitor is a relatively simple task if you have some experience. Be sure that the television is the type that has a power transformer that isolates the 110-volt AC line from the chassis. It is extremely important to avoid putting potentially lethal voltage on the chassis and into your computer. (Many of the late model sets do not incorporate power transformers.)

An article in the May 1978 BYTE, "Convert Your TV Set to a Video Monitor," by Dan Fylstra (see page 22), describes this conversion using a commercial kit. The Pickles & Trout TVM-04 direct-entry video kit will allow a clear display of 64 characters per line. . . . **Steve**

Emulator Programs Provide More Software

Dear Steve,

I recently purchased a Radio Shack Color Computer with the idea of designing a program that would allow it to run the numerous programs on the market written for other computers.

I have thought about approaching the problem from the software end by having

the computer read the tape and, from the signals it received from reading the leader, determine the computer type. From there, it could select the proper simulation mode to understand and be able to run the program. However, I realize that if the program were possible, it would take up all the memory in the computer and the program being translated could not be run. Therefore, I am now trying to approach the hardware end of the problem (which I consider to be much easier than the software approach). The problem is I am not sure how to go about designing the hardware. Are either of my two approaches feasible enough to work with 6809 microprocessor?

I felt that the project could be done because I don't think that there is really that much difference between the 6502 and the 6809 other than the way they record and input information into various computers.

Chris Weaver
East Hartford, CT

The concept of a program that would allow running programs from other computers is sound in theory, but falls apart in practice. Assuming that your program would recognize the tape format of the desired program and enable it to be loaded into your computer's memory, the desired program would still not run. Each computer on the market has its own operating system and monitor. Each computer has its keyboard, screen, and I/O routines located in different areas of memory. A call for a character to be sent to the screen in one program would be totally ignored by another program.

A more than casual difference exists between the instruction sets of the various microprocessors, and the codes for the mnemonics are totally different. A program that would recognize each machine and instruction set could be written but would probably take more memory than you could afford.

A more realistic approach is to write an emulator program. This is a program that simulates the instruction set of another microprocessor. Several articles have been printed in various computer magazines for emulating microprocessors. If you devise an emulator program, it is possible to run programs from a specific computer on your own computer. . . . **Steve**

Calculating Bandwidths

Dear Steve,

It seems to me that there's a lack of information on video monitors used on home computers—not one of descriptions of the various monitors advertised, but of what is required to do what. For example, how much bandwidth is required for a satisfactory 80-column line? How much for a good 80-column line? What do you gain by greater bandwidth? Or, put another way, what does your computer need to use a better bandwidth? Do most monitors accept the same input? What is the result of slightly different sweep rates? (Or is the stability of the sweep rate more critical than its absolute value?) Most monitors seem to have a 75-ohm input, so is coaxial cable required or will a good audio cable do? In short, what criteria or specifications should one look for in selecting a video monitor? I haven't been able to compare any displaying the same data side-by-side.

J. T. Miller
Yucaipa, CA

The bandwidth required for a given line on a video monitor can be calculated by dividing the active-trace time by

the number of horizontal dots. For a monitor with a horizontal-sweep frequency identical to a normal television (15,750 hertz), the total trace time is 1/15,750 = 63.5 µs (microseconds). The active-trace time is this time minus the retrace and blanking time, which is usually about two-thirds of the total or 42 µs. If the character matrix is 7 by 9 with a one blank dot space, then 80 characters will require 640 dots and 42/640 = 65.6 nanoseconds per dot, or 15.2 MHz. For a character matrix of 5 by 7, a bandwidth of 11.4 MHz results.

As the monitor bandwidth is reduced, it is less able to clearly display all of the dots, and smearing results. A 12-MHz monitor is probably the minimum bandwidth required for a satisfactory 80-column display. Monitors with a greater frequency response can display 80-column lines with greater sharpness. A rough estimate of monitor bandwidth can be made visually. If all of the dots in each character in an 80-column line are clearly visible, then the monitor has at least 12 to 15 MHz of bandwidth, depending on the character matrix.

Most monitors have a 75-ohm input and are designed for a composite-video signal (one that contains video information along with the horizontal and vertical sweep). Because the distance from the monitor to the computer is usually only a couple of feet, an audio cable can be used. . . . **Steve**■

In "Ask BYTE," Steve Ciarcia answers questions on any area of microcomputing. The most representative questions received each month will be answered and published. Do you have a nagging problem? Send your inquiry to:

Ask BYTE
c/o Steve Ciarcia
POB 582
Glastonbury CT 06033

If you are a subscriber to The Source, chat with Steve (TEC317) directly. Due to the high volume of inquiries, personal replies cannot be given. Be sure to include "Ask BYTE" in the address.

BYTE's Bits

Universal Medium for Software Distribution

Softech Microsystems recently demonstrated a concept called the Universal Medium. Softech claims that this concept could greatly simplify the distribution of applications programs because it provides the means for a single version of a personal-computer applications program to be read and executed by another machine. The applications program that the company demonstrated was encoded on a single floppy disk and was run without modification on an Apple II, an IBM Personal Computer, a Z80-based system, and on the M68000-based Sage II.

Softech Microsystems points out that widespread use of its Universal Medium concept would mean that only one version of a program would have to be developed and encoded on disks for distribution to personal-computer users. The company credits the portability characteristics of the UCSD Pascal system as responsible for this development.■

What's New?

SYSTEMS



Multi-Personal Computer

Columbia Data Products' Multi-Personal Computer (MPC) is available in an IBM Personal Computer compatible configuration for approximately $4000. This system is based on a 16-bit 8088 and comes with 128K bytes of RAM (random-access read/write memory), dual serial ports, a Centronics port, and a detachable keyboard. Standard features include a 12-inch black-and-white monochrome display, color graphics video adapter, and a dual floppy-disk drive system. The MS-DOS and CP/M-86 operating systems and BASIC and macro assembler languages are supplied.

A wide variety of options are available, including a Z80 CP/M board, a 16-bit Motorola 68000 board, an 8087 mathematics chip, cache buffer, Winchester hard-disk drive, multiple RS-232C interface, and telecommunications and networking support. Also available are multiuser, multitasking operating systems such as MP/M-86 and Oasis-16. High-level language support is provided by BASIC, FORTRAN, COBOL, macro assembler, Pascal, and C. The Xenix operating system will soon be available. For full details, contact Columbia Data Products, 8990 Route 108, Columbia, MD 21045, (301) 992-3400.

Circle 550 on inquiry card.

QDP-100

The QDP-100 microcomputer from Quasar Data Products is an 8-bit Z80A-based system. It comes with dual 8-inch floppy-disk drives, 64K bytes of RAM (random-access read/write memory), cache memory, and CP/M and BASIC. The QDP-100 can be configured as a single-user workstation with the CP/M operating system, or it can serve multiple users when equipped with MP/M software and additional memory. Other features include an online Help system and a menu-style listing of operations.

Options for the QDP-100 include a 10- or 15-megabyte hard disk and up to 256K bytes of RAM. A bulletin describing the QDP-100 is available free by writing to Quasar Data Products Inc., Marketing Department, 10330 Brecksville Rd., Cleveland, OH 44141.

Circle 551 on inquiry card.

ISB 80/85 Has Expandable STD Bus

The Microsystems Group of GE Intersil Systems has introduced the ISB 80/85 microcomputer. It has a slim-line STD bus card cage that can accommodate as many as six additional STD bus cards. The basic 80/85 is built around a 64K-byte RAM card, a 12-inch display, detachable keyboard, and your choice of a Z80 or an 8085 processor card. Mass storage is provided by either two 5¼-inch double-sided double-density floppy-disk drives or a single 5¼-inch floppy disk and a 5¼-inch 10-megabyte Winchester drive. The CP/M 2.2 operating system is standard. Optional scientific, business, and word-processing software packages are offered by the company.

Prices for the ISB 80/85 range from $5990 for a version outfitted with dual floppy-disk drives to $8990 for the system with both the floppy disk and Winchester disk drives. OEM (original equipment manufacturer) prices are available. For details, contact GE Intersil Systems Inc., 1275 Hammerwood Ave., Sunnyvale, CA 94086, (408) 743-4300.

Circle 552 on inquiry card.



Micro-Professor II

Micro-Professor II is now being marketed by Multitech Electronics. The 6502-based MPF-II personal computer offers users color graphics and printing capabilities and comes with a 49-key keyboard, including nine function keys, 64K bytes of RAM (random-access read/write memory), and a 12K-byte Apple-compatible BASIC interpreter. Cassette tape is

used for backup storage. Video-display capabilities include text and low- or high-resolution graphics in 6 colors. The screen format is 24 lines by 40 columns (960 characters), using a 5 by 7 dot matrix. Other standard features include a Centronics interface for parallel printers, an RF (radio frequency) modulator, and an onboard 8-ohm speaker.

Optional software cartridges provide the MPF-II with assembly, Pascal, Logo, and FORTH languages. Hardware options include a 40-column thermal printer, joysticks, and a floppy-disk interface. The MPF-II costs $399; volume discounts are available. Contact Multitech Electronics Inc., 195 West El Camino Real, Sunnyvale, CA 94086, (408) 773-8400.

Circle 553 on inquiry card.



Micro Decision

Morrow Designs is marketing a 4-MHz Z80A-based computer that has a single-sided 5¼-inch floppy-disk drive and a full-featured display terminal. Standard features on this computer, called the Micro Decision, include 64K bytes of RAM (random-access read/write memory), two RS-232C serial ports, detachable keyboard, and the CP/M 2.2 operating system. The Micro Decision has a menu-driven front end to CP/M that can be deactivated by the user, a virtual drive that reassigns to drive A any reference to a nonexisting drive, and the ability to read and write multiple disk formats, such as Osborne, IBM, and Xerox 820. Supplied software includes Micro Mike's Bazic, which is compatible with North Star BASIC, Microsoft's BASIC 80 and the Wordstar word processor, Morrow Designs' Correct-It spelling checker, and Software Products International's Logicalc electronic spreadsheet.

Micro Decision has a suggested list price of $1790. It can be purchased without the display terminal for $1195. A second disk drive is available for $350. Quantity discounts are offered. For complete technical and pricing information, contact Morrow Designs, 5221 Central Ave., Richmond, CA 94804, (415) 525-4715.

Circle 554 on inquiry card.

16-Bit Business Computer

NABU Maunfacturinng Corporation has introduced the NABU 1600, a 16-bit Intel 8086/8087 coprocessor-based business computer. The 1600 has 256K bytes of RAM (random-access read/write memory) that can be expanded up to 512K bytes, a 10-meagbyte micro Winchester disk drive, and a high-density minifloppy-disk drive with 800K bytes of formatted storage. Two operating systems, Xenix and MS-DOS, are supplied with the 1600. Using standard asynchronous/synchronous links, the 1600 can communicate with other computers or it can provide access to broadband cable networks. The 1600 can handle three users simultaneously.

The NABU 1600 has a suggested retail price of $12,995 (Canadian). Full details are available from NABU Manufacturing Corp., 1051 Baxter Rd., Ottawa, Ontario K2C 3P2, Canada, (613) 526-1426.

Circle 555 on inquiry card.

SOFTWARE

IBM Program Development Aids

The Lazycoder-Screen is the first in a series of program and presentation development aids for the IBM Personal Computer from Nelson Data Resources. Lazycoder has 35 built-in functions that let you use your screen for designing images or for entering data. Completed designs can be printed, generated into a BASIC file maintenance program using the screen for data entry, or put together for a slide show. With Lazycoder-Screen, you can create computerized educational aides or help systems, or you can use its filing system option to enter and retrieve information.

Lazycoder—Screen costs $125. A free demonstration kit is available. For more information, contact Nelson Data Resources, Suite 118, 900 South 74th Plaza, Omaha, NE 68114, (402) 397-3030.

Circle 556 on inquiry card.

C Language for Model 16

Softworks Ltd. is marketing a complete C compiler for Radio Shack's Model 16 computer. This version of C is based on Whitesmiths C compiler, a complete implementation of the C language. Cross-compilers for developing Model 16 C programs on different computers are available.

Softworks C costs $950. A documentation package is $30. Dealer inquiries are invited. Contact Softworks Ltd., 607 West Wellington, Chicago, IL 60657, (312) 327-7666.

Circle 557 on inquiry card.

Full-Screen Editor for IBM

PCEdit is a full-screen editor for the IBM Personal Computer from Personal Systems Technology. PCEdit features online helps and prompts, global search and replace, large file editing, block move, and a limited undo capability. It permits full use of all function and editing keys on the IBM's keyboard. Minimum requirements are PC-DOS, one disk drive, and 96K bytes of RAM (random-access read/write memory).

PCEdit comes with complete documentation and full support and service. It's available for $98 at selected Computerland stores or factory-direct from Personal Systems Technology Inc., 22957 La Cadena, Laguna Hills, CA 92653, (714) 859-8871.

Circle 558 on inquiry card.

Fancy Fonts for Epson Printers

Softcraft's Fancy Font personal typesetting system provides Epson printers with a variety of type sets, sizes, and faces. Type sizes range from 8 to 21 points, and Fancy Font lets you specify up to 10 fonts or logo sets for any letter or document. Roman, Sans Serif, Script, and Old English with bold, italic, and regular typefaces are all standard. Word-processing capabilities include text centering, justification, and underlining. Parameters such as page size, tabs, margins, fonts, line spacing, headers, and footers are user-specifiable, and text files can be prepared with any text editor, including Wordstar.

The Fancy Font package comes with the Hershey character database, which contains more than 1500 character and graphics symbols that can be scaled to different sizes and formed into new font sets. Fancy Font costs $180 and is available in a variety of disk formats for CP/M-based systems. For a free brochure, contact Softcraft, Suite 1641, 8726 South Sepulveda Blvd., Los Angeles, CA 90045, (213) 641-3822.

Circle 559 on inquiry card.

Space Sharks Challenges Gamers

Empire II: Interstellar Sharks is a science-fiction game system from Interactive Fantasies. The object of the game is to manuever your way through the webs of bureaucratic red tape and occasional clandestine dealings of large monopolies to achieve success: wealth and a spacecraft for your escape.

Empire II: Interstellar Sharks is available in Applesoft for 48K-byte Apple computers running DOS 3.3. It costs $32.95, including a manual and a softcover novella. Contact Interactive Fantasies, POB 22222, Agoura, CA 91301, (213) 706-0661.

Circle 560 on inquiry card.

McGraw-Hill Releases New Software Line

McGraw-Hill Book Company's newly formed Computing & Educational Software Group develops texts and software for computer courses and other educational areas. Initial offerings are in finance, economics, and graphics. For investment analyses, the company has the Riley-Montgomery Investpak, and for time-series economic forecasting the Hall-Hall-Lillien: MicroTSP is offered. A generic graphics program for constructing and displaying instructional materials, the Ward-Irby: Hypergraphics, is also available.

Future software will touch upon business, engineering, sciences, and other disciplines, as well as text-related and database software, stand-alone computational and tutorial software, and generic software encompassing all areas. For details, contact the Computing & Educational Software Group, McGraw-Hill Book Co., 1221 Avenue of the Americas, New York, NY 10020.

Circle 561 on inquiry card.

Farm Accounting Package

Harris Technical Systems' Agdisk Farm Accounting Package offers farmers and ranchers single-entry accounting with double-entry accuracy on either a cash or accrual basis. Standard functions include entering transactions, the ability to print standard financial reports, special provisions that prevent the accidental loss of data, closing and beginning account periods, and the ability to modify account names, heading, etc. Agdisk will run on IBM, Radio Shack, Commodore, Digital, and Texas Instruments systems.

Agdisk costs $600 and is available at selected Apple and Team Electronics dealers and Computerland stores. The Agdisk manual can be purchased separately for $29.95. For more information, contact Harris Technical Systems, 624 Peach St., Lincoln, NE 68508, (402) 476-2811.

Circle 562 on inquiry card.

Secure Your CP/M Files

Secure is designed to stop unauthorized access to CP/M files. Manufactured by Century Systems, Secure can encrypt any type of file, such as binary machine code, data, or text, making the theft of CP/M data virtually impossible. Files can be repeatedly processed by Secure for greater levels of security. This system uses two user-supplied "keys" to protect files on any Z80-based microcomputer. It can safeguard financial data and customer data, mailing lists, confidential

correspondence, computer programs, or data to be transmitted.

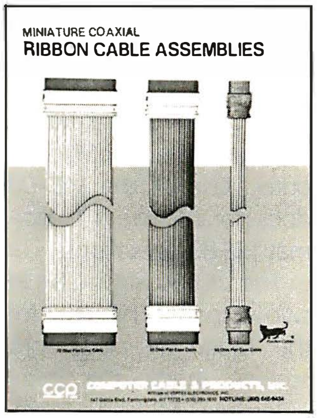
Secure version 3.0 is available in a variety of disk formats for systems running CP/M 2.0 or later. It costs $150. Contact Century Systems Inc., Suite 11B, 12872 Valley View Ave., Garden Grove, CA 92645, (714) 895-3381.
Circle 563 on inquiry card.

Resume Preparation Program

Single Source Solution's Interactive Resume is for people seeking employment. Through a series of questions, Interactive Resume automatically builds your resume, which can be upgraded or tailored to meet the needs of a particular job.

Interactive Resume is available for the Apple, TRS-80, and IBM Personal Computer. A version for CP/M owners is also available. Interactive Resume costs $49.95. For further information and a free software catalog, write to Single Source Solution, POB 578, Concord, CA 94522.
Circle 564 on inquiry card.

PUBLICATIONS



Coaxial Ribbon-Cable Assemblies Brochure

Computer Cable & Products has issued a new brochure describing its line of miniature coaxial ribbon-cable assemblies. Included are full specifications and ordering information on the firm's line of standard dual-latch housing coaxial cable assemblies and custom assemblies. With dual-row latch housing connectors, these miniature coaxial ribbon cables are available with impedances of 50, 75, and 93 ohms and with up to 25 flat conductors. The brochure is available from Computer Cable & Products Inc., Department D21, 147 Gazza Blvd., Farmingdale, NY 11735, (516) 293-1610.
Circle 570 on inquiry card.

Commodore 64 Software Catalog

Commodore Business Machines has announced the availablity of an 8-page catalog describing software for the Commodore 64 microcomputer. Business, financial, word processing, and games software are covered. Contact Commodore Business Machines, The Meadows, 487 Devon Park Rd., Wayne, PA 19807, (215) 687-9750.
Circle 567 on inquiry card.



Guide to Customizing Apple Hardware

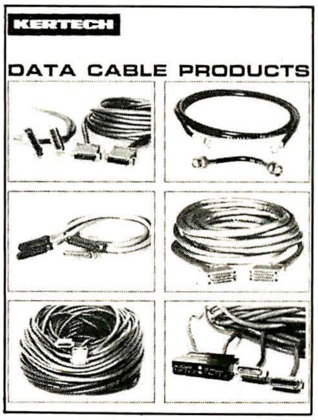
The Custom Apple, a guide to customizing Apple II software and hardware, has been produced by IJG Inc. Coauthored by Winfried Hofacker and Ekkehard Floegel, this book guides you through a series of projects and applications that show you how to custom design hardware for the Apple. The book includes a general information section that has tips on tools, logic diagrams, binary and decimal numbering systems, and wire-wrapping and soldering techniques. In addition, The Custom Apple has a glossary and a parts suppliers source list.

The Custom Apple is available at computer retailers or through the publisher for $24.95. Contact IJG Inc., 1953 West 11th St., Upland, CA 91786. When ordering from the publisher, add $4 for shipping and handling.
Circle 568 on inquiry card.

IBM Products Guide

The current 28-page Buyer's Guide for the IBM Personal Computer describes more than 100 products. Software ranges from a health club membership system to accounting packages. Hardware described includes touch panels, digitizers, light pens, and furniture.

A new edition of the Buyer's Guide for the IBM Personal Computer is available every six weeks. Single copies are $1, and a one-year subscription costs $8. Order your guide from Starware, 1701 K St. NW, Washington, DC 20006, (202) 466-7351.
Circle 569 on inquiry card.



Catalog Spotlights Data-Cable Products

A full range of data-cable assemblies and related accessories for data processing and computer-center applications is described in a catalog from Kertech Corporation. Communications assemblies covered include EIA (Electronic Industries Association) RS-232C, RS-449, V.35, IBM

Serpentine, wideband modems, telephone line, coaxial and twin axial, low-capacitance, null modem, Teflon-insulated cable, and related connector and adapter accessories. Also included in this 20-page catalog are technical specifications, pricing, ordering, and applications information for each assembly and accessory.

The Kertech Data Cable Catalog is available free of charge from Kertech Corp., 1 Map Hill Dr., POB P, Babson Park, MA 02157, (617) 235-5964.

Circle 571 on inquiry card.

Computer Literacy Subject of Textbook

The Random House Spotlight on Computer Literacy worktext, by Ellen Richman, serves as an introduction to computer awareness and programming. Written at the junior high school level, this book is divided into three sections and comes with a teacher's manual that has chapter notes and answers to the exercises found in each chapter.

The first section explains what computers are and how they accept, store, process, and produce processed information. The second section discusses the history of computers and details how they are being used today and how they might be used tomorrow. The last section contains both pencil-and-paper and hands-on activities for BASIC programming instruction so that students can learn how to program Apple II, Atari, PET, or TRS-80 microcomputers.

Twenty-five copies of Ellen Richman's Spotlight on Computer Literacy cost $126.25. For further information, contact Random House, 201 East 50th St., New York, NY 10022, (800) 638-6460; in New York, call (212) 751-2600.

Circle 572 on inquiry card.

PERIPHERALS

Business Graphics Plotter and Software

The Strobe 100 Graphics Plotter and Software package lets you create hardcopy graphics directly from your computer. The Strobe 100 Plotter has a drum platten with X and Y stepper motors. It uses Pilot's Razorpoint or Strobe's Transparency pens to plot on standard 8½- by 11-inch paper. The plotting area is 8 by 10 inches, and the resolution is 500 points per inch. Power requirements are 115 volts AC at 50 Hz or 230 volts AC at 60 Hz. The Strobe 100 measures 3½ inches (8.9 cm) tall by 16¼ inches (41.3 cm) wide by 8½ inches (21.6 cm) deep. Parallel TTL (transistor-transistor logic) I/O is required.

Software for the Strobe 100 includes a stand-alone, menu-driven business graphics program that generates alphanumerics and line, bar, and pie charts. The company also has software that lets you manipulate text and shapes and a program that helps you create reproducible graphics directly from the data files of such electronic spreadsheets as the Apple Business Graphics Package and Visicalc.

Options include a transparency package, pens, an RS-232C cable, and a 50-sheet package of paper. Parallel interface cards make the Strobe 100 Plotter and Software package available for the Apple II and III, Commodore PET and SuperPET, the TRS-80 Model I, the Franklin Ace 1000, the Osborne 1, and S-100 bus systems. An RS-232C serial interface can be obtained. For the name of your local dealer, contact Strobe Inc., 897-5A Independence Ave., Mountain View, CA 94043, (415) 969-5130.

Circle 573 on inquiry card.

The Apple Quartet

Vista Computer Company's Quartet dual floppy-disk drive system gives you the capacity of four standard Apple II drives in the space of a single 5¼-inch drive. Quartet disk drives are styled to complement your Apple, and they work in either dual-side 40-track or single-side 35-track modes.

A complete Quartet package comprises two thinline disk drives, case, controller, and software patches for DOS, CP/M, and Pascal. The suggested list price is $699, which includes a 120-day warranty. For further details, contact Vista Computer Co. Inc., 1317 East Edinger, Santa Ana, CA 92705, (714) 953-0523.

Circle 565 on inquiry card.

TRS-80 Display Expansion Unit

Holmes Engineering's VID-80 is a plug-in adapter that gives your Radio Shack TRS-80 a 24-line by 80-character display. The VID-80 is completely self-contained and has its own memory and video controller. The VID-80 provides enough extra RAM (random-access read/write memory) and logic to convert the TRS-80 to a 64K-byte CP/M computer. Use of the VID-80 does not interfere with normal TRS-80 operations.

The VID-80 is available in two versions. The VX-3 for the Model III plugs into sockets inside the computer; no soldering is required. The VX-1 for the Model I is made up of a small assembly that installs inside the Model I's keyboard and a main printed-circuit board that must be connected into an expansion mainframe, which is available from the manufacturer. The suggested retail price is $279. For more information, contact Holmes Engineering Inc., 3555 South 3200 W, Salt Lake City, UT 84119, (801) 967-2324.

Circle 574 on inquiry card.



Voice-based Learning System

Scott Instruments' VBLS (voice-based learning system), a computer-based educational/training system incorporating speech-recognition technology, is for business, school, industry, and home use. It lets users commmunicate with an Apple II by talking to it. The firm explains that VBLS evolved around a conversational approach to training and education. Instructors or authors determine the educational materials in any language (e.g., VBLS has been trained to recognize English, Korean, German, French, and Japanese) and specify its organization (i.e., fill in the blank or true and false). The self-paced, interactive VBLS environment is controlled by the user's voice.

A VBLS system comprises Scott Instruments' VET-2 voice-entry terminal and VBLS software. It costs $895.95, including manual. Contact the VBLS National Sales Group, Scott Instruments, 1111 Willow Springs Dr., Denton, TX 76201, (817) 387-9514.

Circle 576 on inquiry card.



RS-232C Interface for Commodore 64 and VIC-20

The Model CX-6402, a full RS-232C interface for Commodore's 64 and VIC-20 computers, is made by Xitel Inc. This interface is said to have all the features and levels required to interface any RS-232C device, such as modems and printers. The CX-6402 connects to the computer's user port and permits full use of the machine's eight active RS-232C handshaking signal lines. Standard features include full RS-232C logic levels and the ability to operate at all VIC-20 and Commodore 64 data rates. External RS-232C cables and power supplies are not required.

The CX-6402 comes ready to use. Complete with a 6-foot parallel cable for connection to a printer, the CX-6402 costs $59.95. Further details are available from Xitel Inc., 2678 North Main St. #1, Walnut Creek, CA 94596, (415) 944-9277.

Circle 577 on inquiry card.

Hard-Disk Storage for Xerox 820

An interface that connects the Graymatter line of hard-disk systems to the Xerox 820 microcomputer is available from IQ Systems. The Xerox 820 Transparent Interface gives the microcomputer faster data access, an enlarged database, complete file-to-file analysis and reporting, and low-cost data storage. Graymatter systems use Seagate Technology's 5¼-inch Winchester-type hard-disk drives and are available in expandable 5-, 10-, or 20-megabyte formatted storage capacities.

The Xerox 820 Transparent Interface comes with step-by-step illustrated instructions and an adapter card for interfacing and formatting a Graymatter hard-disk system to the Xerox 820. For more information, write to IQ Systems, 2931 La Jolla St., Anaheim, CA 92806.

Circle 578 on inquiry card.

MISCELLANEOUS

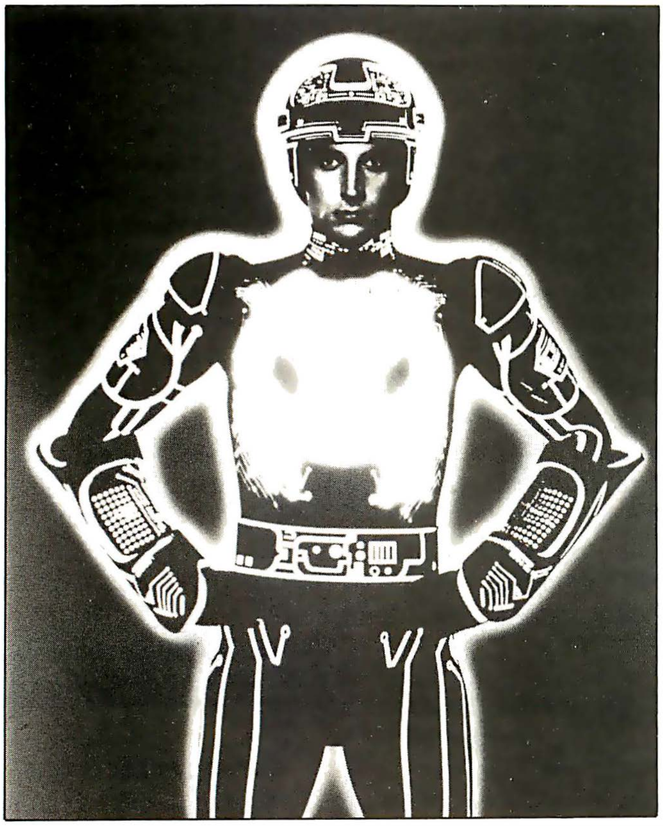
DIP Adapter Plugs

Samtec's DIP adapter plugs are available in ten different sizes and in six different terminal styles. These plugs can be used for interfacing all component leads to DIP (dual in-line package) pinout patterns, and as shorting plugs, I/O plugs, and component mounts. The terminals are precision-machined brass with either gold or tin finish and are available in a choice of styles, including solder-pin, solder-pot, or slotted-head. The body is ⅛-inch-thick glass-filled polyester, UL-rated 94 V-O. All adapters feature pin 1 orientation and counter-bored-through mounting holes.

Prices start at $0.69, in 100-piece lots. Complete specifications are available from Samtec Inc., POB 1147, New Albany, IN 47150, (812) 944-6733.

Circle 586 on inquiry card.

What's New?



Disney Film on Computers

Computers: The Friendly Invasion, a full-color 16-mm film from the Walt Disney Educational Media Company, introduces students to computers. Your pupils are shown how computers work, the types of tasks that computers perform, and the opportunities computers offer in the sciences and arts. Computer graphics and a few scenes from Disney's Tron are featured in this 19½-minute film.

Recommended for grades 5 through 12, Computers: The Friendly Invasion comes with a teacher's guide that provides background information, a glossary of computer terms, suggested teaching strategy, and a bibliography. It costs $419. All Walt Disney 16-mm educational films are available for a free two-week examination. For further information, contact Walt Disney Educational Media Co., 500 South Buena Vista St., Burbank, CA 91521, (800) 423-2555. In California, Alaska, and Hawaii, call collect (213) 840-1726.

Circle 579 on inquiry card.

Relocatable Flowchart Symbols

Proflo manufactures and markets a complete line of preprinted, pressure-sensitive, relocatable flowchart symbols. These symbols eliminate the hassle of erasing and relocating functions whenever flowchart requirements change. The symbols produce a product that is said to be essentially camera ready.

The manufacturer has available a range of starter kits that contain an assortment of standard symbols. For complete details, contact Proflo, 327 East 5300 South, Murray, UT 84107, (801) 266-5368.

Circle 580 on inquiry card.

Practice Keyboards

The Computer Practice Keyboard Company has introduced printed keyboards with each special-function key explained so that it is possible to practice finger positions at any time. Nontypists will find the practice boards helpful aids when attempting to familiarize themselves with standard typewriter-key positions as well as special-key positions.

The portable practice keyboards with a laminated finish are printed on sturdy 8½- by 11-inch stock. They are available for most popular computers, including Apple, Atari, TRS-80, TI-99/4, IBM, Wang, Xerox, Osborne, Heath, Advantage, and Timex/Sinclair. The boards cost $9.95 each, postage paid. When ordering, be sure to mention the name and model number of your computer. Contact the Computer Practice Keyboard Co., 616 9th St., Union City, NJ 07087.

Circle 581 on inquiry card.

Video Screen Cleaner

Visible Computer Supply's Screenclean CRT cleaner removes dirt, dust, and other contaminants that can build up on video screens. This spray-can formula is also said to dissipate the electrostatic charge on screens, which is the primary cause of dust attraction and machine failure. For a 164-page catalog of products, contact Visible Computer Supply Corporation, 3626 Stern Dr., St. Charles, IL 60174, (800) 323-0628; in Illinois, call (312) 377-0990.

Circle 582 on inquiry card.

Sinclair-Compatible Products Available

The 32K RAM Memopak, the Memopak High Resolution Graphics, the Memopak Centronics Parallel Interface, and the Memopak RS232 Printer Interface are Timex/Sinclair-compatible products from Memotech Corporation. The 32K RAM Memopak gives Sinclair computers a full 32K bytes of directly addressable RAM (random-access read/write memory). The suggested retail price is $109.95

A 2K-byte EPROM (erasable programmable read-only memory) monitor containing graphics subroutines, callable by a BASIC USR function or by machine code, comes standard with the Memopak High Resolution Graphics device. This unit gives you fully programmable high-resolution

The last of the American bald eagles?

The last passenger pigeon on earth died in a Cincinnati zoo in 1914.

We don't want the bald eagle to go the same way. There are fewer than 3000 bald eagles left in the lower 48 states.

Civilization has crowded the eagles out of their eyries, yet eagles can live only in wilderness where their nests are undisturbed.

Even where there is uninhabited land, eagles are being killed . . . by careless or malicious hunters, by poisoned meat set out for predators, by insecticides polluting our waters.

We can keep these magnificent birds . . . symbols of our own freedom . . . alive and free to soar our skies. There are ways you can help.

Be careful with pesticides. Read the labels for correct methods of use and disposing of leftover poisons.

Learn to identify the eagle. If you hunt, remember it's against federal law to kill eagles, hawks, falcons and other birds of prey.

Never approach an eagle's roosting or nesting place. It's illegal even to disturb a nest—and you may cause the adult eagles to leave it for good.

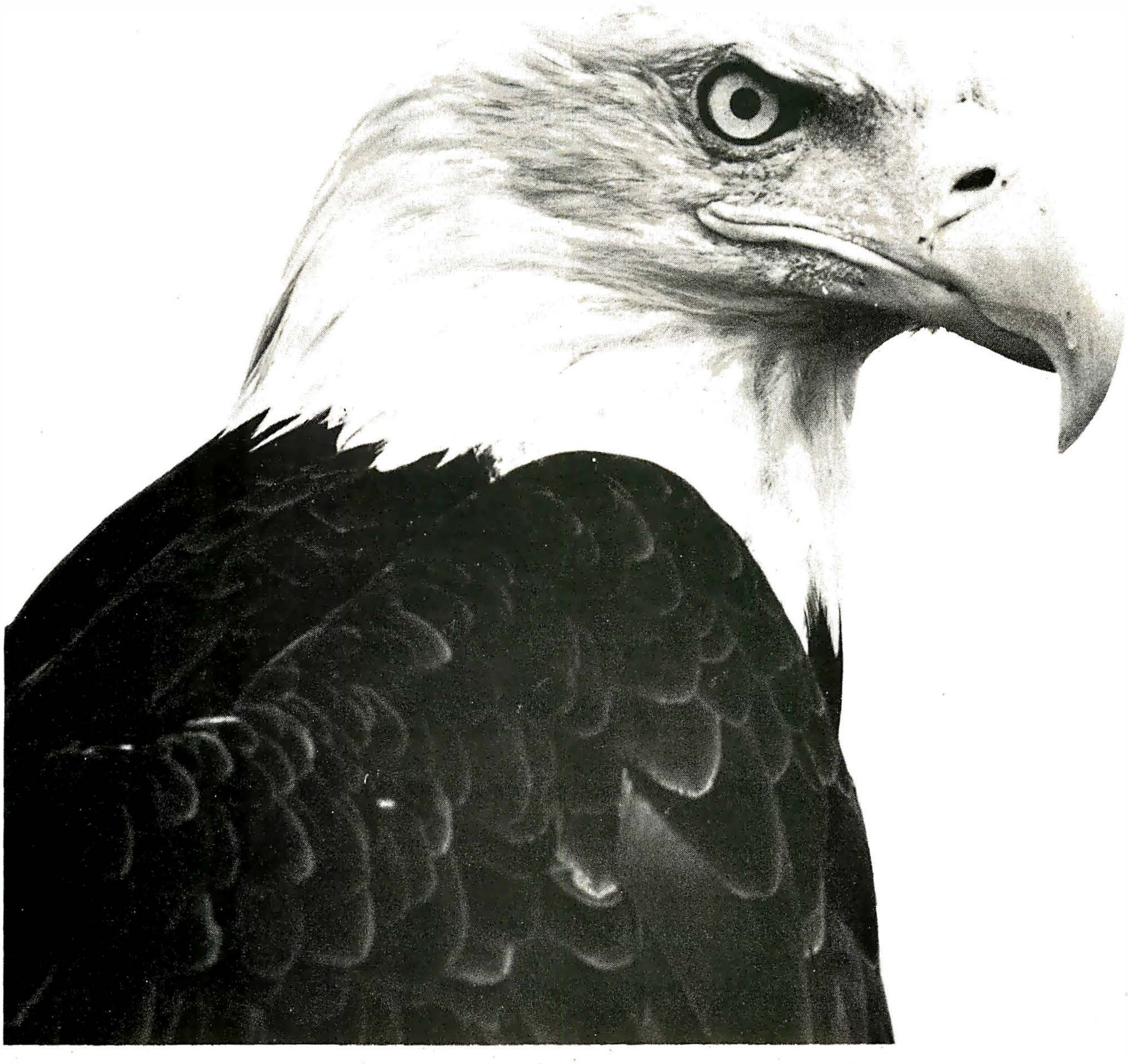
The National Wildlife Federation is working to save the eagle too.

With the help of several American companies, we've purchased land with eagle roosting sites and presented it to the American people.

And the federation has offered a $500 reward for substantial assistance in convicting anyone who kills an eagle.

You can support the National Wildlife Federation's programs to save the bald eagle. Join us. Write the National Wildlife Federation,
Department 101,
1412 16th Street, NW,
Washington, DC 20036.

NATIONAL WILDLIFE FEDERATION

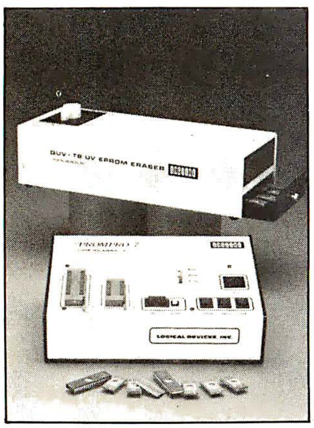


capabilities (192 by 248 pixels), and the number of video pages is limited only by the RAM size (each video page consumes approximately 6.5K bytes of RAM). The High Resolution Graphics Interface costs $144.95.

The Memopak Centronics Interface is fully compatible with Sinclair BASIC. A printer can be activated by the BASIC commands LLIST, LPRINT, and COPY. The resident software in this unit provides the ASCII (American Standard Code for Information Interchange) character set, and the interface permits a full 80-column display. Lowercase characters can be printed by using the inverse character set. This item is available for $104.95.

The Memopak RS232 Printer Interface has many of the same features as the Centronics Interface, but it gives your Sinclair the ability to communicate with peripherals and other computers. It can accommodate data rates between 110 and 19,200 bits per second and accepts modems and printers requiring serial RS-232C input. It costs $139.95.

All Memopak products come with a 10-day money-back guarantee and a six-month warranty. Contact Memotech Corp., Customer Services, 7550 West Yale Ave., Denver, CO 80227, (800) 622-0949; in Colorado, call (303) 986-1516.



EPROM Programmer

The PROMPro-7 from Logical Devices is capable of programming 2716, 2732, 2732A, 2532, 8748, and 8749 EPROMs (erasable programmable read-only memories) either by a remote computer or terminal operation or as a stand-alone unit. PROMPro-7 interfaces to a terminal or computer by means of an RS-232C serial interface. It features user-selectable data rates and the ability to copy one EPROM from another without external control. After programming, each EPROM is verified against the memory's contents.

In single units, the PROMPro-7 costs $489, including personality modules. It's available from Logic Devices Inc., 781 West Oakland Park Blvd., Fort Lauderdale, FL 33311.

Circle 583 on inquiry card.

Video-Taped Short Course on Pascal

A three-part, full-color video-taped short course covering the concepts of computer programming with Pascal is available from Colorado State University's Engineering Renewal and Growth Program. This course represents a structured and disciplined approach to programming that's firmly fixed on programming development, readability, and maintainability. The course was written by Dr. G. R. Johnson and is offered at Colorado State University. For a free description, contact W. L. Somervell Jr., Engineering Renewal and Growth Program, Christman Field, Building 1000, Colorado State University, Fort Collins, CO 80523, (800) 525-4950; in Colorado, call (303) 491-8417.

Circle 584 on inquiry card.

Typesetting on Compuserve

Compuserve, in cooperation with Type Share, is offering subscribers a typesetting service. This system lets users compose and transmit materials directly from their home or place of business at any time of the day or night. Required equipment includes a computer, modem, transmission software to send stored files over telephone lines, and the Type Share manual. Users simply keyboard the material to be typeset, specify type style, size, and column width, save the material to tape or disk, and transmit it over telephone lines to Compuserve. Type Share then processes the material and sends galleys to the author.

The cost for this service is $4 per foor for 4-inch-wide paper or $6 per foot for 8-inch paper. A complete system, including software, Type Share manual, modem, cassette-based VIC-20, supplies, and onsite training, is available for $775. For futher details, contact Compuserve, 5000 Arlington Centre Blvd., Columbus, OH 43220, (614) 457-8600.

Circle 585 on inquiry card.

Where Do New Products Items Come From?

The information printed in the new products pages of BYTE is obtained from "new product" or "press release" copy sent by the promoters of new products. If in our judgment the information might be of interest to the personal computing experimenters and homebrewers who read BYTE, we print it in some form. We openly solicit releases and photos from manufacturers and suppliers to this marketplace. The information is printed more or less as a first-in first-out queue, subject to occasional priority modifications. While we would not knowingly print untrue or inaccurate data, or data from unreliable companies, our capacity to evaluate the products and companies appearing in the "What's New?" feature is necessarily limited. We therefore cannot be responsible for product quality or company performance.

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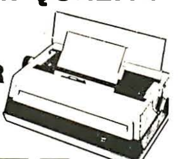
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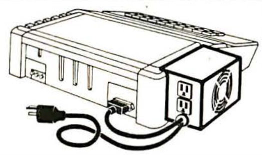
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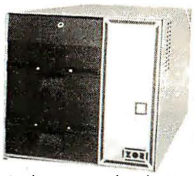
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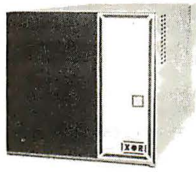
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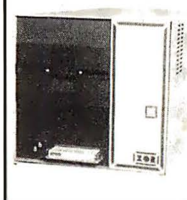
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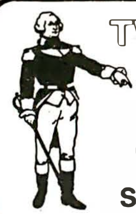
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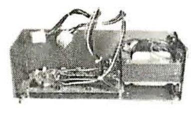
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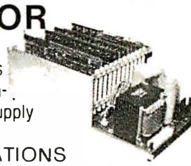
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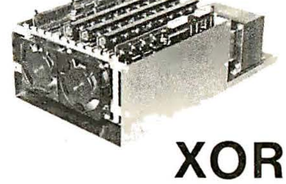
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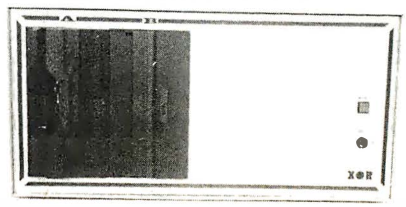
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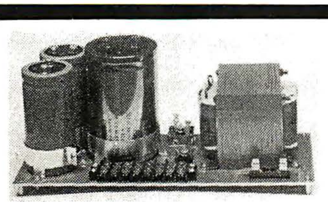
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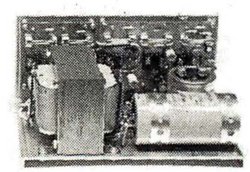
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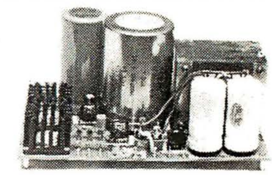
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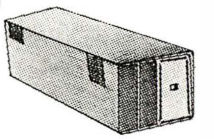
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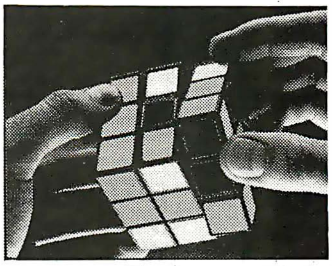
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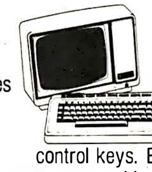
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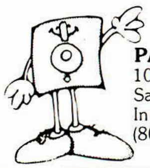
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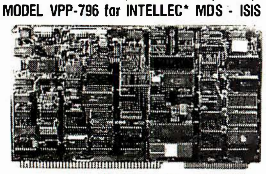
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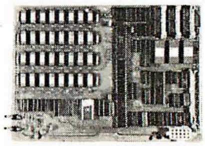
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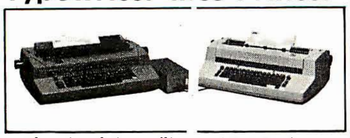
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18	20	36	58
20	29	40	49

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PIN		PIN	
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CD4019	.39
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CD4022	.79
CD4023	.28
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CD4025	.23
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CD4030	.39
CD4035	.85
CD4040	.79
CD4042	.69
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CD4044	.79
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CD4049	.35
CD4050	.35
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VENTURE is a 16" by 20" main board with separate ASCII and HEX keyboards. It runs fast, almost 4 MHz, and has the capability of putting 1.5 megabyte of RAM and ROM on the board along with a variety of inexpensive options.

A 16-channel analog-to-digital converter allows use of joysticks, control functions, instrumentation, temperature sensing, etc. T1 sound generator, software controlled music, Votrax voice synthesizer and real time clock calendar add to its versatility.

VENTURE connects directly to a monitor or to your TV set through an RF modulator. And now for the heart of VENTURE...its video display. VENTURE has a high resolution programmable video display with up to 16,384 user-defined characters, alphanumeric symbols, special graphics or objects, such as space ships, etc. Each character is 8 pixels wide by 16 pixels high, with 2 grayscale maps; it has 256 levels of grayscale plus video invert/compliment and hidden screen update for a "snow" free display. The display is 512 x 512 pixel mapped with 2 planes of video RAM per display, VENTURE video is in short...astounding!

VENTURE has complete software support with full BASIC, 3 ROM monitors, disassembler/assembler/editor. It will run real-time video games, all RCA chip 8 programs and all current Quest 1802 software. VENTURE DOS will accommodate up to four 5¼" double density floppies. A complete 1802 programming book is available. All versions of VENTURE are shipped with a set of manuals written to be understood by the inexperienced as well as experienced user.

A standard 60-pin bus with 5 slots, parallel ports and 2 serial ports with full handshaking (75 to 9600 BAUD) allow expansion into floppy disks, color, EPROM programmer, printer, model of your choice. Later expansion will add a light pen, a universal user programmable music sound board, General Purpose Instrument Bus, and a high resolution color/grayscale pixel mapped video board.

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Expansion Options

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Minimum VENTURE System $195.00

Kit includes CPU and control with 4K of RAM, 1K of scratchpad, 2K monitor, 1861 video graphics, cassette interface and separate HEX keyboard with LED displays for address and output. Power supply is included along with 2 game cassettes. The main board is 16" x 20" and includes space for all of the previously discussed on-board options. Full on-board expansion can be completed for under $1000.00. Call for further details, option prices, etc.

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The Super Elf computer system is now available as a series of bare boards as well as full kits and assembled.

Bare Boards: Super Elf $35.00. Super Expansion $35.00. Power Supply $10.00. S-100 Color $35.00. Dynamic RAM $40.00. Manuals $10.00. Super Basic $45.00.
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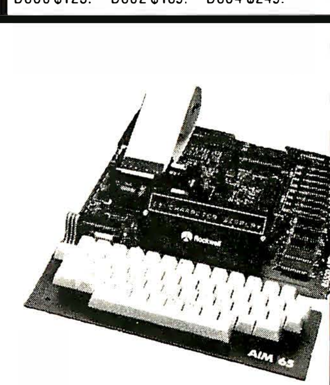
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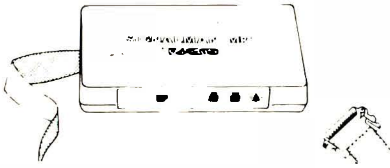
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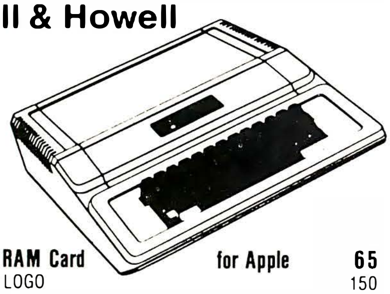
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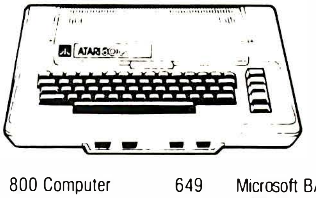
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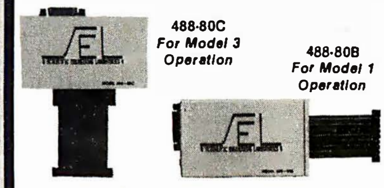
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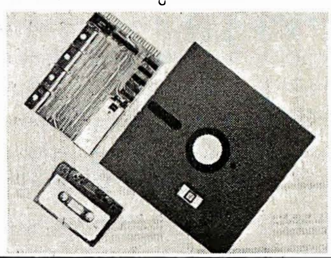
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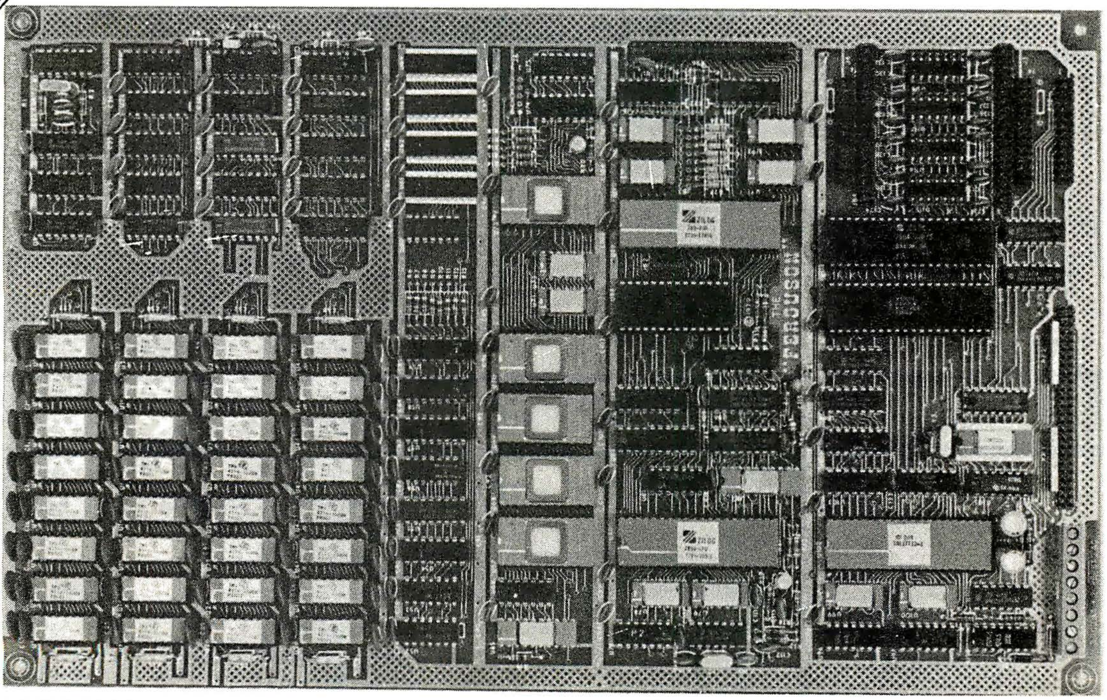
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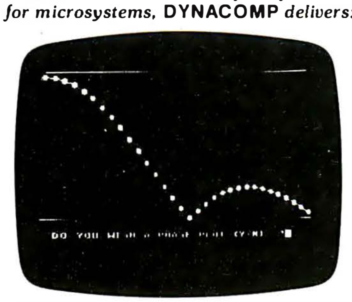
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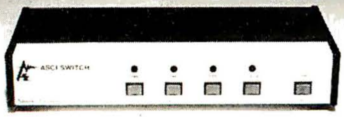
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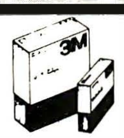
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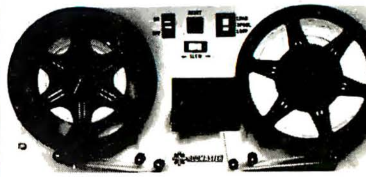
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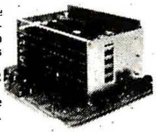
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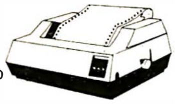
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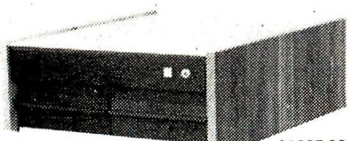
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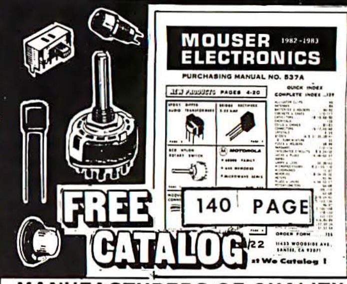
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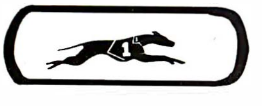
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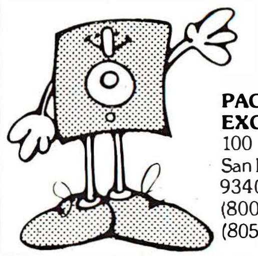
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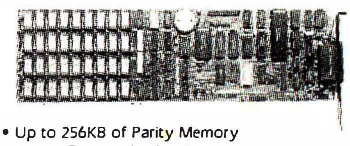
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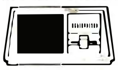
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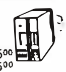
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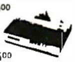
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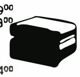
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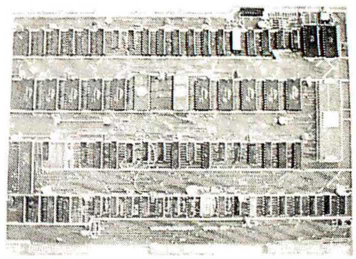
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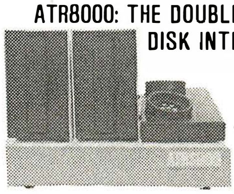
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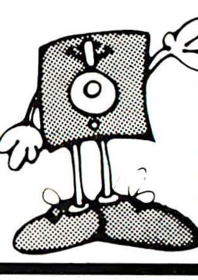
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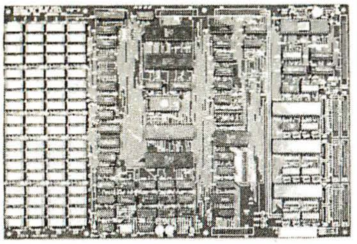
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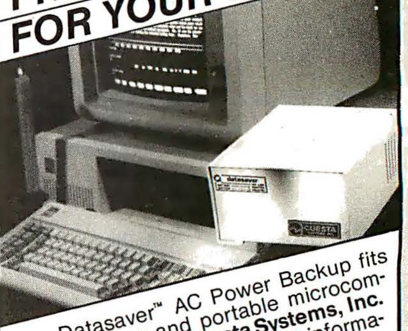
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SN7404N	14	.25
SN7405N	14	.25
SN7406N	14	.29
SN7407N	14	.29
SN7408N	14	.25
SN7409N	14	.25
SN7410N	14	.25
SN7411N	14	.25
SN7412N	14	.35
SN7413N	14	.35
SN7414N	14	.49
SN7416N	14	.25
SN7417N	14	.25
SN7420N	14	.19
SN7421N	14	.35
SN7422N	14	.45
SN7423N	16	.59
SN7425N	14	.29
SN7426N	14	.29
SN7427N	14	.25
SN7428N	14	.49
SN7430N	14	.25
SN7432N	14	.29
SN7437N	14	.25
SN7438N	14	.29
SN7439N	14	.59
SN7440N	14	.19
SN7441N	16	.89
SN7442N	16	.45
SN7443N	16	.99
SN7444N	16	.99
SN7445N	16	.69
SN7446N	16	.69
SN7447N	16	.69
SN7448N	16	.69
SN7450N	14	.19
SN7451N	14	.19
SN7453N	14	.19
SN7454N	14	.19
SN7459A	14	.25
SN7460N	14	.19
SN7470N	14	.29
SN7472N	14	.29
SN7473N	14	.35
SN7474N	14	.35
SN7475N	16	.45
SN7476N	16	.35
SN7479N	14	4.95
SN7480N	14	.69
SN7482N	14	1.19
SN7483N	16	.59
SN7485N	16	.59
SN7486N	14	.35
SN7489N	16	2.25
SN7490N	14	.39
SN7491N	14	.59
SN7492N	14	.39
SN7493N	14	.39
SN7494N	14	.69
SN7495N	14	.49
SN7496N	16	.49
SN7497N	16	2.75
SN74100N	24	1.49
SN74104N	14	.89
SN74105N	14	.89
SN74107N	**14**	**.29**
SN74109N	**16**	**.39**
SN74116N	24	1.49
SN74121N	14	.39
SN74122N	14	.55
SN74123N	16	.49
SN74125N	14	.45
SN74126N	14	.45
SN74132N	14	.49
SN74136N	14	.69
SN74141N	16	.69
SN74142N	16	2.95
SN74143N	24	2.95
SN74144N	24	2.95
SN74145N	16	.59
SN74147N	16	1.49
SN74148N	16	1.19
SN74150N	24	1.19
SN74151N	16	.59
SN74152N	14	.59
SN74153N	16	.59
SN74154N	24	1.25
SN74155N	16	.59
SN74156N	16	.59
SN74157N	**16**	**.59**
SN74160N	16	.69
SN74161N	16	.69
SN74162N	16	.69
SN74163N	16	.69
SN74164N	14	.69
SN74165N	16	.69
SN74166N	16	.89
SN74167N	16	2.79
SN74170N	16	1.29
SN74172N	24	4.95
SN74173N	16	.69
SN74174N	16	.69
SN74175N	16	.69
SN74176N	14	.69
SN74177N	14	.69
SN74179N	16	1.49
SN74180N	14	.69
SN74181N	24	1.95
SN74182N	16	.89
SN74184N	16	1.95
SN74185N	16	1.95
SN74190N	16	.69
SN74191N	16	.69
SN74192N	16	.69
SN74193N	16	.69
SN74194N	16	.69
SN74195N	16	.69
SN74196N	14	.89
SN74197N	14	.89
SN74198N	24	1.19
SN74199N	24	1.19
SN74221N	16	1.19
SN74251N	16	.79
SN74276N	20	1.95
SN74279N	16	.79
SN74283N	16	1.49
SN74284N	16	2.95
SN74285N	16	2.95
SN74365N	16	.55
SN74366N	16	.55
SN74367N	16	.55
SN74368N	16	.55
SN74390N	16	1.49
SN74393N	14	1.49

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Part No.	**Pins	Price
74LS00	14	.25
74LS01	14	.25
74LS02	14	.25
74LS03	14	.25
74LS04	14	.29
74LS05	14	.29
74LS08	14	.29
74LS09	14	.29
74LS10	14	.29
74LS11	14	.35
74LS12	14	.35
74LS13	14	.39
74LS14	14	.59
74LS15	14	.35
74LS20	14	.29
74LS21	14	.29
74LS22	**14**	**.29**
74LS26	14	.29
74LS27	14	.29
74LS28	14	.35
74LS30	14	.29
74LS32	14	.35
74LS33	14	.55
74LS37	14	.35
74LS38	14	.35
74LS40	14	.29
74LS42	16	.55
74LS47	16	.75
74LS48	16	.75
74LS49	14	.75
74LS51	14	.25
74LS54	14	.25
74LS55	14	.29
74LS73	14	.39
74LS74	14	.39
74LS75	16	.39
74LS76	16	.39
74LS78	14	.39
74LS83	16	.65
74LS85	16	.69
74LS86	14	.39
74LS90	14	.55
74LS92	14	.55
74LS93	14	.55
74LS95	14	.79
74LS96	16	.89
74LS107	14	.39
74LS109	16	.39
74LS112	16	.39
74LS113	14	.39
74LS114	14	.39
74LS122	14	.49
74LS123	16	.79
74LS125	14	.49
74LS126	14	.49
74LS132	14	.59
74LS133	16	.59
74LS136	14	.39
74LS138	16	.59
74LS139	16	.59
74LS151	16	.59
74LS153	16	.59
74LS154	24	.99
74LS155	16	.69
74LS156	16	.69
74LS157	16	.69
74LS158	16	.59
74LS160	16	.69
74LS161	16	.69
74LS162	16	.69
74LS163	16	.69
74LS164	14	.69
74LS165	16	1.19
74LS168	16	1.19
74LS169	16	1.19
74LS170	16	1.49
74LS173	16	.69
74LS174	16	.59
74LS175	16	.59
74LS181	24	2.49
74LS190	16	.89
74LS191	16	.89
74LS192	16	.79
74LS193	16	.79
74LS194	16	.69
74LS195	16	.69
74LS197	14	.79
74LS221	16	.89
74LS240	20	1.09
74LS241	20	1.09
74LS242	14	1.09
74LS243	14	1.09
74LS244	20	1.09
74LS245	20	1.49
74LS247	16	1.09
74LS248	16	1.09
74LS249	16	1.09
74LS251	16	.59
74LS253	16	.59
74LS257	16	.59
74LS258	16	.59
74LS260	14	.59
74LS266	14	.69
74LS273	20	1.49
74LS279	16	.49
74LS283	16	.69
74LS290	14	.89
74LS293	14	.79
74LS298	16	.69
74LS352	16	1.29
74LS353	16	1.29
74LS365	16	.49
74LS366	16	.49
74LS367	16	.49
74LS368	16	.49
74LS373	20	1.29
74LS374	20	1.29
74LS375	16	.69
74LS386	14	.45
74LS393	14	1.19
74LS399	16	1.49
74LS670	16	1.49
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74S03	14	.35
74S04	14	.45
74S05	14	.45
74S08	14	.39
74S09	14	.39
74S10	14	.35
74S11	14	.35
74S15	14	.35
74S20	14	.35
74S22	14	.35
74S30	14	.35
74S32	14	.45
74S38	14	.89
74S40	14	.39
74S51	14	.35
74S64	14	.39
74S65	14	.39
74S74	14	.55
74S86	14	.55
74S112	16	.55
74S113	14	.55
74S114	14	.55
74S124	16	2.95
74S133	16	.45
74S134	16	.50
74S135	16	.69
74S136	14	1.39
74S138	16	.89
74S139	16	.89
74S140	14	.55
74S151	16	.99
74S153	16	.99
74S157	16	.99
74S158	16	.99
74S160	16	2.49
74S174	16	.99
74S175	16	.99
74S188*	16	1.49
74S194	16	1.49
74S195	16	1.49
74S196	14	1.49
74S240	20	2.25
74S241	20	2.25
74S242	14	2.49
74S243	14	2.49
74S244	20	2.49
74S251	16	1.19
74S253	16	1.19
74S257	16	1.19
74S258	16	1.19
74S260	14	.79
74S280	14	1.95
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CA3046N	14	.89
CA3059N	14	3.25
CA3060N	16	3.25
CA3080E	8	.89
CA3081N	16	1.49
CA3082N	16	1.49
CA3083N	16	1.49
CA3086N	14	.69
CA3089N	16	1.69
CA3096N	16	1.19
CA3130E	8	1.49
CA3140E	8	.99
CA3160H		1.95
CA3401N	14	.59
CA3600N	14	3.95

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CD4001	**14**	**.29**
CD4002	14	.29
CD4006	14	.89
CD4007	14	.29
CD4009	**16**	**.39**
CD4010	16	.39
CD4011	14	.29
CD4012	**14**	**.15**
CD4013	14	.39
CD4014	16	.79
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CD4021	16	.79
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CD4023	14	.29
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CD4026	16	2.49
CD4027	16	.45
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CD4029	16	.79
CD4030	14	.39
CD4034	24	1.95
CD4035	16	.69
CD4040	16	.79
CD4041	14	.79
CD4042	16	.69
CD4043	16	.79
CD4044	16	.79
CD4046	16	.89
CD4047	14	.89
CD4048	16	.39
CD4049	**16**	**.39**
CD4050	16	.39
CD4051	16	.79
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CD4066	14	.39
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CD4071	14	.29
CD4072	14	.29
CD4073	14	.29
CD4075	14	.29
CD4076	16	.79
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CD4526	16	1.19
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CD4583	16	2.49
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MC14419	16	7.95
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MC6802CP	40	MPU w/Clock and RAM	7.95
INS8035N-6	40	MPU—8-bit (6MHz)	5.95
INS8039N-6	40	CPU-Sgl. chip 8-bit (128 bts. Ram)	5.95
INS8040N-6	40	CPU (256 bytes RAM)	5.95
INS8070N	40	CPU (64 bytes RAM)	11.95
INS8073N	40	CPU w/Basic MicroInterpreter	14.95
P8085A	40	CPU	5.95

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Part No.	**Pins	Function	Price
Z80	40	CPU (MK3880N)(780C) 2MHz	$4.95
Z80-CTC	28	Counter Timer Circuit	5.95
Z80-DART	40	Dual Asynchronous Rec./Trans.	11.95
Z80-DMA	40	Direct Memory Access Circuit	15.95
Z80-PIO	40	Parallel I/O Interface Controller	5.95
Z80-SIO/0	40	Serial I/O (TxCB and RxCB Bonded)	15.95
Z80-SIO/1	40	Serial I/O (Lacks DTRB)	15.95
Z80-SIO/2	40	Serial I/O (Lacks SYNCB)	15.95
Z80-SIO/9	40	Serial I/O	15.95
Z80A	40	CPU (MK3880N-4)(780C-1) 4MHz	5.95
Z80A-CTC	28	Counter Timer Circuit	5.95
Z80A-DART	40	Dual Asynchronous Rec./Trans.	11.95
Z80A-DMA	40	Direct Memory Access Circuit	17.95
Z80A-PIO	40	Parallel I/O Interface Controller	5.95
Z80A-SIO/0	40	Serial I/O (TxCB and RxCB bonded)	16.95
Z80A-SIO/1	40	Serial I/O (Lacks DTRB)	16.95
Z80A-SIO/2	40	Serial I/O (Lacks SYNCB)	16.95
Z80A-SIO/9	40	Serial I/O	16.95
Z80B	40	CPU (MK3880N-6) 6MHz	11.95
Z80B-CTC	28	Counter Timer Circuit	13.95
Z80B-PIO	40	Parallel I/O Interface Controller	13.95
Z8001	48	CPU Segmented	51.95
Z8002	40	CPU Non-Segmented	55.95
Z8030	40	Serial Comm. Controller	44.95
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Part No.	**Pins	Function	Price
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MC6821	40	Peripheral Inter. Adapt (MC6820)	4.95
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MC6830L8	24	1024x8-bit ROM (MC68A30-8)	10.95
MC6850	24	Asynchronous Comm. Adapter	4.95
MC6852	24	Synchronous Serial Data Adapter	5.75
MC6860	24	0-600bps Digital MODEM	9.95
MC6862	24	2400bps Modulator	12.95
MC6880A	16	Quad 3-state bus. trans. (MC8T26)	2.25
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MC68488P	40	General Purpose Int. Adapter	8.95
MC68652P2	40	Multi. Protocol Comm. Controller	24.95
MC68661P8	28	Enhanced Prog. Comm. Int.	8.95

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Part No.	**Pins	Function	Price
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TMS5501	40	Synchronous Data Interface (SIRC)	14.95
INS8154	40	128 Byte RAM 16-Bit I/O	13.95
INS82C06	20	Octal D Flip Flop Tri-State (74C374)	2.49
DP8212	24	8-bit Input/Output (74S412)	2.25
DP8214	24	Priority Interrupt Control	3.95
DP8216	16	Bi-Directional Bus Driver	2.25
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DP8228	28	System Cont./Bus Driver (74S428)	3.49
DP8238	28	System Controller (74S438)	4.49
INS8243	24	I/O Expander for 48 Series	5.95
INS8245	18	16-Key Keyboard Encoder (74C922)	4.49
INS8246	20	20-Key Keyboard Encoder (74C923)	4.95
INS8247	28	Display Controller (74C911)	8.95
INS8248	28	Display Controller (74C912)	8.95
INS8250N	40	Asyn. Comm. Element (INS8250)	10.95
DP8251	28	Prog. Comm. I/O (USART)	4.49
DP8253	24	Prog. Interval Timer	6.95
DP8255	40	Prog. Peripheral I/O (PPI)	4.49
DP8257	40	Prog. DMA Control	7.95
DP8259	28	Prog. Interrupt Control	6.95
DP8275	40	Prog. CRT Controller	29.95
DP8279	40	Prog. Keyboard/Display Interface	6.95
DP8303	20	8-Bit Tri-State Bi-Directional Trans.	3.95
DP8304	20	8-bit Bi-Directional Receiver	2.49
DP8307	20	8-bit Bi-Directional Receiver	2.49
DP8308	20	8-bit Bi-Directional Receiver	2.49
DP8310	20	Octal Latched Peripheral Driver	4.95
DP8311	20	Octal Latched Peripheral Driver	4.95

MICROPROCESSOR MANUALS & DATA BOOKS

Part No.	Description	Price
M-Z80	User Manual	7.50
M-COP1802	User Manual	7.50
M-2650	User Manual	5.00
10400	1982 Intel Data Book (1405pg.)	14.95
30001	1981 Nat. CMOS Book (628 pg.)	6.95
30002	1980 Nat. Interface Book (640 pg.)	6.95
30003	1982 Nat. Linear Book (1952pg.)	11.95
30005	1981 Nat. TTL Book (624pg.)	9.95
30008	1980 Nat. Memory Data Book (464pg.)	6.95
30011	1980 Nat. Linear Applications (736 pg.)	15.95
30013	1983 Zilog Data Book (641 pg.)	7.95
205610	1981 Intel Peripheral Design (828 pg.)	9.95

DYNAMIC RAMS

Part No.	**Pins	Description	Price
1103	16	1024x1 (300ns)	.99
4027	**16**	**4096x1 (250ns)**	**2.49**
4116N-2	16	16,384x1 (150ns)	1.89 - 8/14.95
4116N-3	16	16,384x1 (200ns)	1.69 - 8/12.95
4116N-4	16	16,384x1 (250ns)	1.49 - 8/10.95
4164N-150	16	65,536x1 (150ns)	7.95 - 8/59.95
4164N-200	16	65,536x1 (200ns)	7.49 - 8/54.95
MM5261	18	1024x1 (300ns)	.49 - 8/1.95
MM5262	**22**	**2048x1 (365ns)**	**.49 — 8/1.95**
MM5270	18	4096x1 (250ns) MK4096	4.95
MM5280	22	4096x1 (200ns) 2107	3.95
MM5290-2	16	16,384x1 (150ns)	1.89 - 8/14.95
MM5290-3	16	16,384x1 (200ns)	1.69 - 8/12.95
MM5290-4	16	16,384x1 (250ns)	1.49 - 8/10.95
MM5298-3	16	8192x1 (200ns)	1.69

STATIC RAMS

Part No.	**Pins	Description	Price
1101	16	256x1 (650ns)	1.49
2101	22	256x4 (450ns) 8101	2.49
2102	16	1024x1 (350ns)	.89
21L02	16	1024x1 (450ns) L.P.	1.49
2111	18	256x4 (450ns) 8111	2.95
2112	16	256x4 (450ns) MOS	2.95
2114	18	1024x4 (450ns)	1.95 - 8/13.95
2114L	18	1024x4 (450ns) L.P.	2.25 - 8/15.95
2114-2	18	1024x4 (200ns)	2.25 - 8/15.95
2114L-2	18	1024x4 (200ns) L.P.	2.49 - 8/17.95
2141-3	18	4096x1 (150ns)	3.95
2147	18	4096x1 (70ns)	4.95
2148	18	1024x4 (70ns)	8.95
TMS4044	18	4096x1 (450ns)	3.95
TMS4045	18	1024x4 (450ns)	3.95
5101	22	256x4 (450ns) CMOS	4.95
MM5257	18	4096x1 (450ns) 4044	4.95
HM6116P-3	24	2048x8 (150ns) CMOS	7.95
HM6116-4	24	2048x8 (200ns) CMOS	6.95
HM6116LP-4	24	2048x8 (200ns) L.P. CMOS	7.95
7489	16	16x4 (50ns) 3101	2.25
74C920	22	256x4 (250ns) CMOS (6551)	3.95
74C921	18	256x4 (250ns) CMOS	3.95
74C929	16	1024x1 (250ns) CMOS (6501)	3.95
74C930	18	1024x1 (250ns) CMOS (6518)	3.95
74S189	16	16x4 (35ns) 93405	1.95
74S200	16	256x1 (80ns) 93410	3.95
74S206	16	256x1 (60ns) 93411	3.95
74S289	16	16x4 (35ns) 3101	2.25
82S10	16	1024x1 (50ns) O.C. (93415)	3.95
82S25	16	16x4 (50ns) O.C. (74S289)	2.25

EPROMS

Part No.	**Pins	Description	Price
1702A	24	256x8 (1us)	4.95
2708	24	1024x8 (450ns)	3.95
2708-5	24	1024x8 (550ns) SM00246	2.95
TMS2516	24	2048x8 (450ns) 2716	6.95
TMS2532	24	4096x8 (450ns) NMC2532	9.95
TMS2564	28	8192x8 (450ns)	19.95
TMS2716	24	2048x8 (450ns) 3 voltage	7.95
2716	24	2048x8 (450ns)	4.95
2716-1	24	2048x8 (350ns)	6.95
2732	24	4096x8 (450ns)	9.95
27580	24	1024x8 (450ns) single +5V	2.95
MM2764	28	8192x8 (450ns)	16.95
MM2764-3	28	8192x8 (300ns)	19.95

PROMS

Part No.	**Pins	Description	Price
74S188	16	32x8 PROM O.C. (6330-1)	1.49
74S287	16	256x4 PROM T.S. (6301-1)	1.95
74S288	16	32x8 PROM T.S. (6331-1)	1.95
74S387	16	256x4 PROM O.C. (6300-1)	1.95
74S471	20	256x8 PROM T.S. (6309-1)	5.95
74S472	20	512x8 PROM T.S. (6349-1)	4.95
74S473	20	512x8 PROM O.C. (6348)	4.95
74S474	24	512x8 PROM T.S. (DM87S296N)	4.95
74S475	24	512x8 PROM O.C. (6340)	4.95
74S478	24	1024x8 PROM T.S. (TBP28S86)	8.95
74S570	16	512x4 PROM O.C. (6305)	2.95
74S571	16	512x4 PROM T.S. (6306)	2.95
74S572	18	1024x4 PROM O.C. (6352)	4.95
74S573	18	1024x4 PROM T.S. (82S137)	4.95
82S23	16	32x8 PROM O.C. (27S18)	2.95
82S115	24	512x8 PROM T.S. (27S15)	9.95
82S123	16	32x8 PROM T.S. (27S19)	2.95
82S126	16	256x4 PROM O.C. (27S20)	3.95
82S129	16	256x4 PROM T.S. (27S21)	3.95
82S130	16	512x4 PROM O.C. (27S12)	5.95
82S185	18	2048x4 PROM T.S. (TBP24S81)	9.95
DM87S180N	24	1024x8 PROM O.C. (82S180)	9.95
DM87S181N	24	1024x8 PROM T.S. (82S181)	9.95
DM87S184N	18	2048x4 PROM O.C. (82S184)	9.95
DM87S185N	18	2048x4 PROM T.S. (82S185)	9.95
DM87S190N	24	2048x4 PROM O.C. (82S190)	19.95
DM87S191N	24	2048x8 PROM T.S. (82S191)	19.95

DATA ACQUISITION

Part No.	**Pins	Description	Price
DC10		Mostek DC/DC Convert. +5V to -9V	2.95
MC3470P	18	Floppy Disk Read AMP System	4.95
MC1408L7	16	7-bit D/A Converter (DAC0607LCN)	2.49
MC1408L8	18	8-bit D/A Converter (DAC0808LCN)	2.95
ADC0804	20	8-bit A/D Converter (1 LSB)	3.49
DAC0806	16	8-bit D/A Converter (0.78% Lin.)	1.95
ADC0809	28	8-bit A/D Converter (8-Ch. Multi.)	4.49
AY-5-1013A	**40**	**30K Baud Uart (TR1602)**	**4.95**

INTERSIL

*Evaluation Kits

Part No.	**Pins	Function	Price
7045IPI	28	CMOS Precision Timer	14.95
7045EV/Kit*	28	Stopwatch Chip, XTL	19.95
7106CPL	40	3½ Digit A/D (LCD Drive)	9.95
7106EV/Kit*	40	IC, Circuit Board, Display	34.95
7107CPL	40	3½ Digit A/D (LED Drive)	11.95
7107EV/Kit*	40	IC, Circuit Board, Display	29.95
7116CPL	40	3½ Digit A/D LCD Dis. HLD	16.95
7117CPL	40	3½ Digit A/D LED Dis. HLD	15.95
7201IUS		Low Battery Volt Indicator	2.25
7205IPG	24	CMOS LED Stopwatch/Timer	12.95
7205EV/Kit*	24	Stopwatch Chip, XTL	14.95
7206CJPE	16	Tone Generator	4.95
7206CEV/Kit*	16	Tone Generator Chip, XTL	7.95
7207AIPD	14	Oscillator Controller	5.95
7207AEV/Kit*	14	Freq. Counter Chip, XTL	7.95
7208IPI	28	Seven Decade Counter	15.95
7209IPA	8	Clock Generator	3.95
7215IPG	24	4 Func. CMOS Stopwatch CKT	13.95
7215EV/Kit*	24	4 Func. Stopwatch Chip, XTL	14.95
7216AIJI	28	8 Digit Univ. Counter C.A.	29.95
7216CIJI	28	8 Digit Freq. Counter C.A.	24.95
7216DIPI	28	8 Digit Freq. Counter C.C.	19.95
7217IJI	28	4 Digit LED Up/Down Counter C.A.	10.95
7217AIPI	28	4 Digit LED Up/Down Counter C.C.	11.95
7224IPL	40	LCD 4½ Digit Up Counter DRI	10.95
7226AIJL	40	8 Digit Univ. Counter	29.95
7226AEV/Kit*	40	5 Function Counter Chip, XTL	74.95
7240IJE	16	CMOS Bin Prog. Timer/Counter	4.95
7242IJA	8	CMOS Divide-by-256 RC Timer	2.25
7250IJE	16	CMOS BCD Prog. Timer/Counter	6.00
7260IJE	16	CMOS BCD Prog. Timer/Counter	5.25
7555IPA	8	CMOS 555 Timer	1.45
7556IPD	14	CMOS 556 Timer	2.20
7611BCPA	8	CMOS Op Amp Comparator 5MV	2.25
7612BCPA	8	CMOS Op Amp Ext. Cmvr. 5MV	2.95
7621BCPA	8	CMOS Dual Op Amp Comp. 5MV	3.95
7631CCPE	16	CMOS Tri Op Amp Comp. 10MV	5.35
7641CCPD	14	CMOS Quad Op Amp Comp. 10MV	7.50
7642CCPD	14	CMOS Quad Op Amp Comp. 10MV	7.50
7660CPA	8	Voltage Converter	2.95
8038CCPD	14	Waveform Generator	3.95
8048CCPE	16	Monolithic Logarithmic Amp	16.95
8069CCQ		50ppm Band—GAP Volt Ref. Diode	2.50
8211CPA	8	Volt Ref/Indicator	2.95
8212CPA	24	Volt Ref/Indicator	2.95

30009 1983 INTERSIL Data Book (1356p.) $9.95

74C—C/MOS

Part No.	**Pins	Price
74C00	14	.35
74C02	14	.35
74C04	14	.29
74C08	14	.35
74C10	14	.35
74C14	14	.59
74C20	14	.35
74C30	14	.35
74C32	14	.39
74C42	16	1.39
74C48	16	1.95
74C73	14	.79
74C74	14	.69
74C85	16	1.95
74C86	14	.39
74C89	16	5.95
74C90	14	1.19
74C93	14	1.19
74C95	14	1.39
74C107	14	.89
74C151	16	2.49
74C154	24	3.49
74C157	16	2.25
74C160	16	1.19
74C161	16	1.19
74C162	16	1.19
74C163	16	1.19
74C164	14	1.49
74C173	16	.79
74C174	16	1.19
74C175	16	1.19
74C192	16	1.49
74C193	16	1.69
74C195	16	1.39
74C221	16	1.95
74C240	20	1.95
74C244	20	1.95
74C373	20	2.49
74C374	20	2.49
74C901	14	.59
74C903	14	.59
74C906	14	.59
74C911	28	8.95
74C912	28	8.95
74C915	18	1.19
74C917	28	8.95
74C922	18	4.49
74C923	20	4.95
74C925	16	5.95
74C926	18	5.95
80C95	16	.39
80C97	16	.39

NEW PRODUCT! 74HC High Speed CMOS

Part No.	**Pins	Price
74HC00	14	.75
74HC02	14	.75
*74HCU04	14	.75
74HC08	14	.75
74HC10	14	.75
74HC20	14	.75
74HC27	14	.75
74HC74	14	.99
74HC75	16	.99
74HC86	14	.99
74HC109	16	1.39
74HC138	16	1.49
74HC139	16	1.49
74HC147	16	1.19
74HC151	16	1.19
74HC157	16	1.19
74HC160	16	1.79
74HC161	16	1.79
74HC164	14	1.79
74HC174	16	1.39
74HC175	16	1.39
74HC242	14	2.79
74HC243	14	2.79
74HC251	16	1.19
74HC266	14	.99
74HC280	14	4.95
74HC373	20	3.95
74HC374	20	3.95
74HC533	20	3.95
74HC534	20	3.95
74HC4075	14	.75
74HC4538	16	2.95
74HC4543	16	4.95

*74HCU04 is unbuffered. All others are buffered. Send $.30 for Data Sheet.

NEW Programmable Array Logic (PALS)

Part No.	**Pins	Function	Price
PAL10H8	20	Octal 10-Input AND-OR Gate Array (High Output)	$5.95
PAL12H6	20	Hex 12-Input AND-OR Gate Array (High Output)	5.95
PAL14H4	20	Quad 14-Input AND-OR Gate Array (High Output)	5.95
PAL10L8	20	Octal 10-Input AND-OR-Invert Gate Array (Low Output)	5.95
PAL12L6	20	Hex 12-Input AND-OR-Invert Gate Array (Low Output)	5.95
PAL14L4	20	Quad 14-Input AND-OR-Invert Gate Array (Low Output)	5.95
PAL16L8	20	Octal 16-Input AND-OR-Invert Gate Array (Low Output)	9.95
PAL16R8	20	Octal 16-Input Register AND-OR Gate Array	9.95
PAL16R6	20	Hex 16-Input Register AND-OR Gate Array	9.95
PAL16R4	20	Quad 16-Input Register AND-OR Gate Array	9.95

30012 1982 NATIONAL PAL Data Book (176p.) .. $5.95

LINEAR

Part No.	**Pins	Price
TL071CP	8	.79
TL072CP	8	1.39
TL074CN	14	1.95
TL081CP	8	.59
TL082CP	8	1.19
TL084CN	14	1.95
LM301CN	8	.35
LM302H		1.95
LM304H		1.95
LM305H		.99
LM307CN	8	.45
LM308CN	8	.69
LM309K		1.25
LM310CN	8	1.75
LM311CN	8	.69
LM312H		2.49
LM317T		1.19
LM317K		3.95
LM318CN	8	1.95
LM319N	14	1.95
LM320K-5		1.35
LM320K-12		1.35
LM320K-15		1.35
LM320T-5		.89
LM320T-12		.89
LM320T-15		.89
LM323K		5.95
LM324N	14	.59
LM337T		1.95
LM338K		6.95
LM339N	14	.69
LM340K-5		1.35
LM340K-12		1.35
LM340K-15		1.35
LM340T-5		.79
LM340T-12		.79
LM340T-15		.79
LM348N	14	.99
LM350K		4.95
LF355N	8	1.10
LF356N	8	1.10
LM370N	14	4.49
LM373N	14	3.95
LM377N	14	1.95
LM380N	14	.89
LM381N	14	1.79
LM382N	14	1.39
LM384N	14	1.79
LM386N-3	8	.89
TL494CN	16	2.95
TL496CP	8	1.19
NE510A	14	4.95
NE529A	14	2.95
NE531V	8	2.95
NE536H		8.95
NE540H		4.95
NE544N	14	2.95
NE550A	14	1.95
NE555V	8	.35
LM556N	14	.69
NE564N	16	2.95
LM565N	14	1.19
LM566CN	8	1.49
LM567V	8	.89
NE570N	16	3.95
LM703CN	8	1.19
LM709N	14	.49
LM710N	14	.69
LM711N	14	.79
LM723N	14	.55
LM733N	14	1.00
LM739N	14	1.95
LM741CN	8	.35
LM747N	14	.69
LM748N	8	.59
LM1310N	14	1.49
LM1458CN	8	.59
LM1488N	14	.69
LM1489N	14	.69
LM1496N	14	1.95
LM1800N	16	1.49
LM1889N	18	1.95
LM1896N	14	2.95
LM2002T		1.49
LM3189N	16	1.59
LM3900N	14	.59
LM3905CN	8	1.19
LM3909N	8	.99
LM3914N	18	3.49
LM3915N	18	3.49
LM3916N	18	3.49
RC4136N	**14**	**1.26**
RC4151NB	8	1.95
ICL8038B	14	3.95
LM13060N	8	1.19
LM13600N	16	1.19

MORE AVAILABLE

CONNECTORS

DB25 — D Subminiature (meets RS232)

Part No.	Description	Price
DE9P	9 Pin Plug	$1.79
DE9S	9 Pin Socket	1.95
DA15P	15 Pin Plug	1.95
DA15S	15 Pin Socket	2.95
DB25P	**25 Pin Plug (Meets RS232)**	**2.49**
DB25S	**25 Pin Socket (Meets RS232)**	**3.25**
DB25P-831	25 Pin Right Angle Plug	4.95
DB25S-831	25 Pin Right Angle Socket	5.25
DC37P	37 Pin Plug	4.95
DC37S	37 Pin Socket	5.95
DD50P	50 Pin Plug	5.95
DD50S	50 Pin Socket	6.95

Accessories

Part No.	Description	Price
DE-9H	Hood for DE-9 Series Connectors	$1.19
DA-15H	Hood for DA-15 Series Connectors	1.29
DB25H	Hood for DB25 Series Connectors	1.25
DC37H	Hood for DC37 Series Connectors	1.39
DD50H	Hood for DD50 Series Connectors	1.49
D20418-2	2 screws for mtg. connectors to a panel	.79

Solder Eyelet/Wire Wrap Edge Card

Part No.	Cnts.	Sp.	Description	Price
15/30SE	15/30	.156	Solder Eyelet	$1.79
18/36SE	18/36	.156	Solder Eyelet	1.95
22/44SE	22/44	.156	Solder Eyelet	2.49
22/44PC	22/44	.156	PC type (no mtg. ears)	.99
50/100SE	50/100	.125	Solder Eyelet	9.95
22/44WW	22/44	.156	Wire Wrap - Level 3	4.95
67031-5	22/44	.156	WW (Pins .0625x.03x.75)	3.95
R-681-1	50/100	.125	Wire Wrap - Level 3	7.95
R-681-2	50/100	.125	Wire Wrap - Level 1	6.95

RF Coaxial Connectors

Part No.	Description	Price
PL259	UHF Plug	$ .89
SO239	UHF Panel Receptacle	.69
PL258	UHF Straight Adapter	.89
UG175/U	UHF Reducing Adapter	.49
UG88/U	BNC Plug	1.49
UG89/U	BNC Jack	1.69
UG306/U	BNC Angle Adapter	2.49
UG260/U	BNC Plug	1.49
UG1094/U	BNC Bulkhead Receptacle	.89

IC SOCKETS

For Socket Required, See Column After The IC Part No.

LOW PROFILE (TIN) SOCKETS

	1-9	10-99	100-999
8 pin LP	.16	.14	.13
14 pin LP	.17	.15	.14
16 pin LP	.19	.17	.16
18 pin LP	.26	.24	.23
20 pin LP	.30	.27	.25
22 pin LP	.31	.28	.26
24 pin LP	.33	.30	.28
28 pin LP	.40	.37	.35
36 pin LP	.46	.42	.39
40 pin LP	.49	.46	.43

— Soldertail Standard Tin & Gold Also Available —

WIRE WRAP (GOLD) SOCKETS LEVEL #3

	1-9	10-99	100-999
8 pin WW	.49	.45	.42
10 pin WW	.65	.62	.59
14 pin WW	.65	.62	.59
16 pin WW	.69	.65	.61
18 pin WW	.89	.85	.79
20 pin WW	1.09	1.05	.99
22 pin WW	1.25	1.19	1.15
24 pin WW	1.29	1.23	1.18
28 pin WW	1.59	1.50	1.45
36 pin WW	1.85	1.75	1.69
40 pin WW	1.99	1.89	1.79

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

Value	1-9	10-99	100+
10 pf	.08	.06	.05
22 pf	.08	.06	.05
47 pf	.08	.06	.05
100 pf	.08	.06	.05
220 pf	.08	.06	.05
470 pf	.08	.06	.05
.001µF	.08	.06	.05
.0047µF	.08	.06	.05
.01µF	.08	.06	.05
.022µF	.09	.07	.06
.047µF	.09	.07	.06
.1µF	.15	.12	.10

MINI. ALUMINUM ELECTROLYTIC CAPACITORS

Axial	1-99	100-499	500+
.47/50V	.16	.14	.10
1.0/50V	.19	.16	.12
3.3/50V	.17	.15	.11
4.7/25V	.18	.15	.11
10/25V	.18	.15	.11
10/50V	.19	.16	.12
22/25V	.19	.16	.12
22/50V	.24	.20	.18
47/25V	.25	.21	.19
47/50V	.29	.25	.23
100/25V	.28	.24	.22
100/50V	.41	.37	.34
220/25V	.39	.34	.33
220/50V	.49	.45	.41
470/25V	.54	.49	.45
1000/16V	.79	.69	.61
2200/16V	.89	.79	.69

Radial	1-99	100-499	500+
.47/25V	.15	.13	.12
.47/50V	.16	.14	.13
1.0/16V	.15	.13	.12
1.0/25V	.16	.14	.13
1.0/50V	.17	.15	.14
4.7/16V	.15	.13	.12
4.7/25V	.16	.14	.13
4.7/50V	.17	.15	.14
10/16V	.15	.13	.12
10/25V	.16	.14	.13
10/50V	.17	.15	.14
47/50V	.25	.21	.19
100/16V	.21	.17	.14
100/25V	.25	.23	.21
100/50V	.37	.34	.31
220/16V	.25	.21	.19
470/25V	.35	.31	.27

$10.00 Minimum Order — U.S. Funds Only
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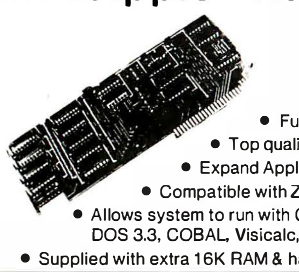
1/83 *PHONE ORDERS WELCOME — (415) 592-8097 Telex: 176043*

Circle 216 on inquiry card.

ADVANCED COMPUTER PRODUCTS

SEND $2.00 for 1983 CATALOG

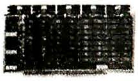
16K Apple™ Ramcard



LIST 195
ACP
$59^95

- Full 1 year warranty
- Top quality — gold fingers
- Expand Apple II 48K to 64K
- Compatible with Z-80 Softcard™
- Allows system to run with CP/M™, PASCAL, DOS 3.3, COBAL, Visicalc, etc.
- Supplied with extra 16K RAM & has (2) LED's

32K STATIC RAM



2 or 4 MHz Expandable Uses 2114L's

16K 4 MHz Kit	$159.95
16K 4 MHz A&T	217.95
32K 4 MHz Kit	$129.95 ~~289.95~~
• 32K 4 MHz A&T	• 339.00
BARE BOARD	39.95
BareBdw/allpartslessmem.	99.95

BARE BOARDS

S-100 Sound Board	$34.95
8080A CPU	34.95
32K Static RAM (2114)	34.95
8K EPROM (2708)	24.95
2708/2716 EPROM	34.95
ACP Proto Board	22.95
Vector 8800 Proto	22.20
Vector 8803 11 slot MB	29.95
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8 Slot MotherBd (Expandable)	34.95
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Apple Sound Board	24.95

UV "EPROM" ERASER



Model UVs-11E
$79.95
Holds 4 EPROM's at a time
Model S-52T $325.00

16K Memory Expansion Kits for Apple/TRS-80

8 pcs 4116 16K
200/250nS
Specify computer $12.95
CALL FOR VOLUME PRICING

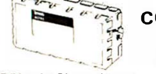
"D" SUB CONNECTORS



Unreal price. DB37 male, DB25 female. Gold PC mount with mounting holes. Mfg. AMP. Specify 25 or 37 pins.

BD37 $2.50 DB25 $1.95

Astec RF Modulator



for COLOR & B/W

P/N 1082 Channel 3 or 4 $6.95

1200 BAUD MODEM IC



Features:
- 1200 Baud
- 40 Pin
- 5Volts Only

SL1200 .... $129.00

64K CMOS RAM

S100 (200nS)

Uses 2716's or 6116's $299^00

Assembled & Tested $399.00

MOSTEK 4K RAMS



29¢ ea.

200,000 pieces in stock — priced to move. Same as MK4027 except 1mS refresh. MK4015 4Kx1 RAM.

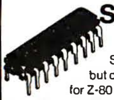
STEPPER MOTOR



Operates by applying 12VDC in one direction and then reversing polarity (or square wave). Uses 12VDC, Clock Wise Rotation, Rated 3 RPM at 4 P.P.S. with a 5 degree stepping angle.

ACP PRICE
$4^95 ea. 10 for $39.95

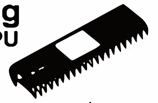
4K STATIC RAM SELL-OFF



10/$9.90

Same as TMS4044 but designed specifically for Z-80 based systems. This is a full-spec 4Kx1 RAM, 450nS. OrderP/N Zilog6104-4 whilesupplylasts.

Zilog Z8 CPU with TINY BASIC



Debug prog. $49.95
Plus 6132 companion quasi-static RAM 29.95

Stepper Motor



NEW
USED IN DATA PRODUCTS PRINTER
$19.95 ea.

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DB25S Female	3.75
Hood	1.25
Set with Hood, Sale	7.50
22/44 S/T, KIM	2.95
43/86 S/T, MOT	6.50
50/100 S-100 Connector W/W	4.95
50/100 S-100 Connector S/T	3.95

PARALLEL ALPHA NUMERIC PRINTER



19 Column Printer prints 16 numerical columns plus 3 columns which have math, alpha and other notations. Each wheel has 12 positions with position 12 blank. Position 11 on numerical columns have decimal point or #. Utilizes 2.75" wide adding machine tape and a dual color ink ribbon. Input data parallel with four bit BCD comparator circuit (schematic provided). Print rate, 3 lines per second. Operating voltage 22-28VDC with typical cycle time of 340mS. Size 6½"W x 3⅛"H x 5⅜"Dp. New. $9.95 ea. 3/$27

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Z8002	69.00	2901	9.90	8035	14.95
Z80	9.95	2901A	14.95	8039	12.95
Z80A	11.95	9900JL	49.95	8073N	34.95
F-8 (3850)	16.95	6502	9.95	8755	49.95
2650	16.95	6502A	16.95	8748	49.95
1802	9.75	IM6100	29.95	6809	30.00
8080A	4.75	6800	11.75	8086	49.95
8085	14.95	6800B	19.95	68000	129.95

RAMS

CALL FOR QTY PRICING

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8264-64K	5.95	411	5.99	5298	1.49
4116-2	1.99	414	4.69	6508	4.50
4116-2	8/12.95	1101	.99	6518	6.79
2101	3.99	1103	.99	6561	3.79
2102	.79	4027	4.69	6604	3.99
21L02-2	1.49	4044	3.99	6605	7.99
21L02-4	1.29	4050	4.69	9130	8.99
2111	3.49	4060	4.69	9140	8.99
2112	3.49	4096	3.99	93415	6.99
2114	1.99	4115	1.49	93425	6.99
2114L-2	3.25	4200	7.95		
2114L-4	2.29	4402	1.99		
2125	6.99	5280	4.60		

64K only $5.95

SUPPORT

8155	$9.95	8259	$8.95	68047	$22.95
8156	9.95	8275	19.95	68488	19.95
8202	29.95	8279	9.50	46505	22.95
8205	2.69	6810	4.75	6520	6.95
8212	2.75	6820	6.50	6522	9.95
8214	4.95	6821	6.50	6530-X	24.95
8216	2.75	6828	10.50	6532	17.95
8224	2.95	6834	16.95	6551	19.95
8226	2.95	6845	22.95	Z80-PIO	6.50
8228	3.95	6847	27.95	Z80A-PIO	9.50
8243	9.50	6850	5.25	Z80-CTC	6.50
8250	14.95	6852	5.25	Z80A-CTC	9.50
8251	6.50	6860	10.95	Z80-DMA	19.95
8253	11.95	6862	10.95	Z80A-DMA	27.95
8255	4.50	6875	5.95	Z80-SIO	24.95
8257	9.50	6880	2.49	Z80A-SIO	29.95

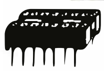
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2764 (8Kx8) TS	$69.95	2708 (450nS)	$5.75
2732 (4Kx8) TS	12.95	2708 (650nS)	5.25
2716/2516; 5V (2Kx8) TS	7.95	1702A	5.75
TMS2716, 5V, 12V	17.95	MM5203AQ	14.50
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2513-ADM3 (5V) Lower	14.95	8038 Function Generator	4.50
MCM66710 ASCII Shifted	12.95	MC4024VCO	2.95
MCM66740 Math Symbol	13.95	LM566VCO	1.95
MCM66750 Alpha Control	13.45	XR2206 Function Generator	5.25
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1793DD,DS Floppy	44.95	IM6402	7.95
1797DD,DS Floppy	54.95	IM6403	8.95
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2143 Clock Generator	18.95	1671B Astros	24.95
8700 8 bit Binary	13.50	MC14411	11.95
8701 10 bit Binary	22.00	4702	14.95
8703 8 bit TS	13.50	WD1941	9.95
9400 Volt to Freq Conv.	7.25	COM5016	16.95
8750 3½ Digit BCD	13.95	INS8250	15.95
1408L6 6 bit	3.95	AY5-2376	13.75
1408L8 8 bit	5.95	AY5-3600	13.75
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SOCKETS



LOW PROFILE SOCKETS (TIN)

	1-24	25-49	50-100
8 pin LP	.16	.15	.14
14 pin LP	.20	.19	.18
16 pin LP	.22	.21	.20
18 pin LP	.29	.28	.27
20 pin LP	.34	.32	.30
22 pin LP	.29	.27	.24
24 pin LP	.38	.37	.36
28 pin LP	.45	.44	.43
40 pin LP	.60	.59	.58

3L WIREWRAP SOCKETS (GOLD)



	1-24	25-49	50-100
8 pin WW	.55	.54	.49
10 pin WW (Tin)	.65	.63	.58
14 pin WW	.75	.73	.67
16 pin WW	.80	.77	.70
18 pin WW	.95	.90	.81
20 pin WW	1.15	1.08	.99
22 pin WW	1.45	1.35	1.23
24 pin WW	1.35	1.26	1.14
28 pin WW	1.60	1.53	1.38
40 pin WW	2.20	2.09	1.89

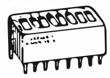
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78H05K	$5.95	LM1414N	$1.90
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78M.G.	1.49	MC1488N	.99
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LM301CN	.35	LM1556N	1.50
LM304H	1.98	LM1820N	.95
LM305H	1.89	LM1850N	.95
LM306H	3.25	LM1889N	3.10
LM307CN	.29	LM2111N	1.75
LM308CN	.98	LM2900N	.99
LM309K	1.49	LM2901N	2.50
LM310CN	1.25	LM2917N	2.95
LM311D/CN	.89	CA3013T	2.19
LM312H	1.75	CA3018T	1.99
LM317T	1.70	CA3021T	3.49
LM318CN	1.49	CA3023T	2.99
LM319N/H	1.25	CA3035T	2.75
LM320K-XX*	1.35	CA3039T	1.29
LM320T-XX*	1.39	CA3046N	1.29
LM320H-XX*	1.25	LM3053N	1.49
LM323K	4.95	CA3059N	3.19
LM324N	.95	CA3060N	3.19
LM337K	5.95	CA3062N	4.95
LM338K	6.95	LM3065N	1.49
LM339N	.95	CA3080T	1.29
LM340K-XX*	1.75	CA3081N	1.69
LM340T-XX*	1.25	CA3082N	1.69
LM340H-XX*	1.25	CA3083N	1.55
LM344H	1.95	CA3086N	.80
LM348N	1.20	CA3089N	2.99
LM350K	5.60	CA3096N	3.49
LM358CN	.98	CA3097N	1.99
LM360N	1.49	CA3130T	1.30
LM372N	1.95	CA3140T	1.19
LM376N	3.75	CA3146N	2.49
LM377N	2.75	CA3160T	1.19
LM380CN/N	1.25	CA3190N	1.95
LM381N	1.79	CA3410N	.59
LM383T	1.95	MC3423N	1.49
LM386N	1.25	MC3460N	3.95
LM387N	1.40	SG3524N	3.95
LM390N	1.95	CA3600N	3.39
NE531V/T	3.75	LM3900N	.59
NE555V	.39	LM3905N	1.19
NE558N	.98	LM3909N	.98
NE561T	19.95	LM3914N	3.75
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NE587V/H	1.50	RC4131N	2.95
NE592N	2.75	RC4136N	1.10
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LM711N/H	.39	ULN2001	1.25
LM715N	1.95	ULN2003	1.50
LM723N/H	.65	SN75450N	.59
LM733N/H	.98	SN75451N	.35
LM739N	1.15	SN75452N	.49
LM741CN/H	.33	SN75453N	.49
LM741CN-14	.19	SN75454N	.49
LM747N/H	.75	SN75491N	.89
LM748N/H	.39	SN75492N	.89
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74S00	$ .39	74S124	3.89	74S244	$2.99
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74S03	.45	74S134	.66	74S253	1.35
74S04	.52	74S135	1.15	74S257	1.29
74S05	.52	74S136	1.89	74S258	1.29
74S08	.49	74S138	1.29	74S260	.75
74S09	.49	74S139	1.29	74S280	2.79
74S10	.42	74S140	.73	74S287	2.99
74S11	.42	74S151	1.29	74S288	2.55
74S15	.42	74S153	1.29	74S373	3.10
74S20	.42	74S157	1.29	74S374	3.10
74S22	.42	74S158	1.29	74S387	2.75
74S30	.42	74S160	2.79	74S471	7.95
74S32	.49	74S174	1.49	74S472	7.95
74S38	1.19	74S175	1.49	74S473	7.95
74S40	.49	74S188	2.69	74S474	9.95
74S51	.42	74S194	1.89	74S475	9.95
74S64	46	74S195	1.89	74S570	5.75
74S65	.46	74S196	1.89	74S571	5.75
74S74	.69	74S240	2.75	74S572	8.95
74S86	.72	74S241	2.75	74S573	8.95
74S112	.72	74S242	2.99	74S940	2.90
74S113	.72	74S243	2.99	74S941	2.90
74S114	.72				

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2 Position	$ .99	7 Position	$1.39
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- 105cfm free air delivery
- 4.68" sq. x 1.50" deep. Weight - 17 oz.

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7400	$ .19	7475	$ .38	74161	$ .88
7401	.22	7476	.34	74162	.89
7402	.22	7479	4.60	74163	.87
7403	.22	7480	.49	74164	.87
7404	.22	7482	.95	74165	.87
7405	.23	7483	.55	74166	1.20
7406	.35	7485	.65	74167	1.95
7407	.35	7486	.35	74170	1.69
7408	.26	7489	1.75	74172	4.75
7409	.23	7490	.39	74173	.79
7410	.22	7491	.57	74174	.89
7411	.29	7492	.45	74175	.85
7412	.29	7493	.45	74176	.75
7413	.39	7494	.69	74177	.75
7414	.59	7495	.65	74179	1.34
7416	.29	7496	.69	74180	.75
7417	.29	7497	2.90	74181	1.75
7420	.22	74100	2.90	74182	.75
7421	.35	74107	.32	74184	2.25
7422	.29	74109	.37	74185	2.25
7423	.29	74116	1.95	74186	9.95
7425	.29	74121	.29	74188	3.90
7426	.29	74122	.39	74190	1.15
7427	.25	74123	.59	74191	1.15
7429	.45	74125	.39	74192	.65
7430	.23	74126	.44	74193	.85
7432	.29	74128	.59	74194	.85
7437	.25	74132	.89	74195	.68
7438	.29	74136	.75	74196	.85
7439	.29	74139	.95	74197	.85
7440	.19	74141	.79	74198	1.39
7441	.79	74142	2.95	74199	1.39
7442	.57	74143	2.95	74221	1.19
7443	.95	74144	2.95	74251	.95
7444	.95	74145	.62	74273	1.05
7445	.79	74147	1.95	74276	1.89
7448	.79	74148	1.20	74279	.75
7447	.65	74150	1.09	74283	1.40
7448	.79	74151	.67	74284	3.90
7450	.19	74152	.67	74285	3.90
7451	.19	74153	.67	74290	1.25
7453	.19	74154	1.19	74298	.95
7454	.19	74155	.78	74365	.68
7459	.25	74156	.78	74366	.68
7460	.23	74157	.69	74367	.68
7470	.29	74158	1.85	74368	.68
7472	.29	74159	2.49	74390	1.45
7473	.34	74160	.68	74393	1.90
7474	.34			74490	1.90

74LS00

74LS00	$ .26	74LS113	$ .43	74LS245	$2.20
74LS01	.28	74LS114	.43	74LS247	1.10
74LS02	.28	74LS122	.55	74LS248	1.10
74LS03	.28	74LS123	1.19	74LS249	1.19
74LS04	.35	74LS124	1.35	74LS251	1.40
74LS05	.28	74LS125	.89	74LS253	1.40
74LS08	.28	74LS126	.52	74LS257	.85
74LS09	.35	74LS132	.79	74LS258	.98
74LS10	.28	74LS136	.49	74LS259	2.95
74LS11	.39	74LS138	.85	74LS260	.65
74LS12	.33	74LS139	.85	74LS261	2.49
74LS13	.47	74LS145	1.25	74LS266	.59
74LS14	.95	74LS148	1.49	74LS273	1.75
74LS15	.33	74LS151	.79	74LS275	4.40
74LS20	.26	74LS153	.79	74LS279	.59
74LS21	.33	74LS154	1.70	74LS283	.99
74LS22	.33	74LS155	1.19	74LS290	.99
74LS26	.33	74LS156	.99	74LS293	.99
74LS27	.33	74LS157	.85	74LS295	1.10
74LS28	.33	74LS158	.75	74LS298	1.19
74LS30	.26	74LS160	1.05	74LS324	1.75
74LS32	.33	74LS161	1.15	74LS347	1.95
74LS33	.55	74LS162	1.05	74LS348	1.95
74LS37	.45	74LS163	1.05	74LS352	1.19
74LS38	.39	74LS164	1.19	74LS353	1.19
74LS40	.26	74LS165	.69	74LS363	1.49
74LS42	.79	74LS166	2.48	74LS385	.69
74LS47	.79	74LS168	1.15	74LS366	.69
74LS48	.95	74LS169	1.15	74LS367	.69
74LS51	.26	74LS170	1.99	74LS368	.69
74LS54	.29	74LS173	.69	74LS373	1.69
74LS55	.29	74LS174	.69	74LS374	1.69
74LS73	.45	74LS175	.89	74LS375	.69
74LS74	.42	74LS181	2.20	74LS377	1.95
74LS75	.59	74LS190	1.15	74LS385	1.95
74LS76	.45	74LS191	1.15	74LS386	.65
74LS78	.45	74LS192	.98	74LS390	1.95
74LS83A	.79	74LS193	.98	74LS393	1.95
74LS85	1.19	74LS194	1.15	74LS395	1.70
74LS66	.45	74LS195	.95	74LS399	2.35
74LS90	.57	74LS196	.89	74LS424	2.95
74LS92	.75	74LS197	.69	74LS668	1.75
74LS93	.75	74LS221	1.15	74LS670	2.29
74LS95	.88	74LS240	1.69	81LS95	1.69
74LS96	.98	74LS242	1.69	81LS96	1.69
74LS107	.45	74LS243	1.69	81LS97	1.69
74LS109	.45	74LS244	1.49	81LS98	1.69
74LS112	.43				

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4014	1.39	4051	1.10	4501	.39
4015	1.15	4052	1.10	4502	1.65
4016	.59	4053	1.10	4503	.69
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4019	.45	4059	9.25	4507	.95
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4021	1.19	4066	.75	4510	1.19
4022	1.15	4069	.35	4511	1.19
4023	.29	4070	.49	4512	1.39
4024	.75	4071	.35	4515	2.75
4025	.25	4072	.35	4516	1.45
4027	.65	4073	.35	4518	1.39
4028	.85	4075	.35	4520	1.25
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4030	.45	4077	.35	4556	.99
4031	3.25	4078	.35	4566	2.25
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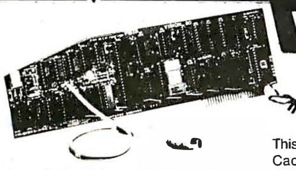
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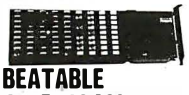
as reviewed in May BYTE pg. 266

This is the widely discussed Cadillac 80 column card for the Apple II. The Vision 80 responds to more Apple text screen commands than any other board. It supports PASCAL, Microsofts Z80 Softcard and can be used as an intelligent terminal.

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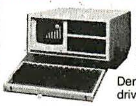
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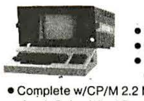
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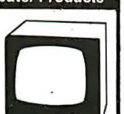
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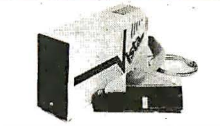
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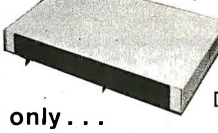
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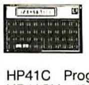
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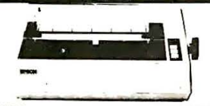
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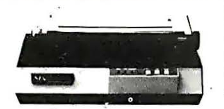
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74LS04	.24	74LS132	.75	74LS260	.60
74LS05	.24	74LS136	.49	74LS266	.49
74LS08	.24	74LS137	.95	74LS273	1.60
74LS10	.24	74LS138	.75	74LS275	3.25
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74LS27	.24	74LS157	.75	74LS353	1.49
74LS28	.30	74LS158	.75	74LS363	1.49
74LS30	.24	74LS160	.95	74LS364	1.95
74LS32	.36	74LS161	.95	74LS365	.89
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74LS38	.35	74LS164	.95	74LS368	.69
74LS40	.30	74LS165	.95	74LS373	.99
74LS42	.49	74LS166	1.95	74LS374	1.69
74LS47	.75	74LS168	1.69	74LS377	1.40
74LS48	.75	74LS169	1.69	74LS378	1.15
74LS49	.75	74LS170	1.69	74LS379	1.35
74LS51	.30	74LS173	.75	74LS385	1.89
74LS54	.35	74LS174	.89	74LS386	.59
74LS55	.35	74LS175	.89	74LS390	1.79
74LS63	1.20	74LS181	1.99	74LS393	1.79
74LS73	.39	74LS189	9.50	74LS395	1.59
74LS74	.44	74LS190	.89	74LS399	1.59
74LS75	.49	74LS191	.89	74LS424	2.89
74LS76	.39	74LS192	.89	74LS447	.75
74LS78	.49	74LS193	.89	74LS490	1.89
74LS83	.75	74LS194	.89	74LS668	1.65
74LS85	.95	74LS195	.89	74LS669	1.85
74LS86	.39	74LS196	.79	74LS670	2.10
74LS90	.65	74LS197	.79	74LS674	9.50
74LS91	.79	74LS221	1.10	74LS682	2.99
74LS92	.65	74LS240	.95	74LS683	2.39
74LS93	.59	74LS241	.95	74LS684	2.39
74LS95	.79	74LS242	1.79	74LS685	2.39
74LS96	.79	74LS243	1.79	74LS688	2.39
74LS107	.39	74LS244	.95	74LS689	2.39
74LS109	.39	74LS245	1.89		
74LS112	.39	74LS247	.79	81LS95	1.65
74LS113	.39	74LS248	1.20	81LS96	1.65
74LS114	.49	74LS249	.89	81LS97	1.65
74LS122	.45	74LS251	1.25	81LS98	1.65

UARTS

AY5 1014	5.85
AY5 1013	3.90
AY5 2376	10.95
TR 1602	3.90
1M 6402	7.85
1M 6403	8.85

LEDS

Jumbo Red	10/1.00
Jumbo Green	6/1.00
Jumbo Yellow	6/1.00

DIP SWITCHES

4 Position	.85
5 Position	.90
6 Position	.90
7 Position	.90
8 Position	.95

EXAR

XR 2206	3.75
XR 2207	3.75
XR 2208	3.90
XR 2211	5.25
XR 2240	3.25

RCA

CA 3010	.95
CA 3013	1.99
CA 3023	2.75
CA 3035	2.49
CA 3039	1.25
CA 3046	1.25
CA 3053	1.45
CA 3059	2.90
CA 3060	2.90
CA 3065	1.75
CA 3080	1.10
CA 3081	1.65
CA 3082	1.65
CA 3083	1.65
CA 3086	.80
CA 3089	2.90
CA 3130	1.25
CA 3140	1.15
CA 3146	1.75
CA 3160	1.15
CA 3401	.59
CA 3600	3.45

CMOS

4000	.25	4086	.90	74C89	4.50
4001	.30	4093	.90	74C90	1.75
4002	.30	4098	2.49	74C93	1.75
4006	.90	4099	1.90	74C95	1.75
4007	.25	4502	.90	74C107	1.00
4008	.90	4503	.60	74C150	5.75
4009	.45	4508	1.90	74C151	2.25
4010	.45	4510	.90	74C154	3.25
4011	.30	4511	.90	74C157	1.75
4012	.30	4512	.90	74C160	2.00
4013	.45	4514	1.20	74C161	2.00
4014	.90	4515	2.20	74C162	2.00
4015	.90	4516	1.50	74C163	2.00
4016	.45	4518	1.20	74C164	2.00
4017	1.15	4519	1.20	74C165	2.00
4018	.90	4520	1.20	74C173	2.00
4019	.45	4522	1.20	74C174	2.25
4020	.90	4526	1.20	74C175	2.25
4021	.90	4527	1.90	74C192	2.25
4022	1.10	4528	1.20	74C193	2.25
4023	.35	4531	.90	74C195	2.25
4024	.75	4532	1.90	74C200	5.75
4025	.35	4538	1.90	74C221	2.25
4026	1.60	4539	1.90	74C373	2.75
4027	.60	4543	2.70	74C374	2.75
4028	.75	4555	.90	74C901	.80
4029	.90	4556	.90	74C902	.85
4030	.45	4581	1.90	74C903	.85
4034	2.90	4582	1.90	74C905	10.95
4035	.85	4584	.90	74C906	.95
4040	.90	4585	.90	74C907	1.00
4041	1.20			74C908	2.00
4042	.75	80C07	.90	74C909	2.75
4043	.75	80C95	.90	74C910	9.95
4044	.75	80C96	.90	74C911	10.00
4046	.90	80C97	.90	74C912	10.00
4047	.90	80C98	1.15	74C914	1.95
4049	.50			74C915	2.00
4050	.50	74C00	.35	74C918	2.75
4051	.90	74C02	.35	74C920	17.95
4053	.90	74C04	.35	74C921	15.95
4060	1.39	74C08	.35	74C922	5.59
4066	.75	74C10	.35	74C923	5.95
4068	.39	74C14	1.50	74C925	6.75
4069	.30	74C20	.35	74C926	7.95
4070	.35	74C30	.35	74C927	7.95
4071	.30	74C32	.50	74C928	7.95
4072	.30	74C42	1.75	74C929	19.95
4073	.30	74C48	1.20	74C930	19.95
4075	.30	74C73	.65		
4076	.90	74C74	.85	14409	12.90
4078	.30	74C76	.80	14410	12.90
4081	.30	74C83	1.95	14411	11.90
4082	.30	74C85	1.95	14412	12.90
4085	.90	74C86	.95	14419	4.90

DoKay Computer Products, Inc.
3250 Keller Street, #9
Santa Clara, CA 95050
(800) 538-8800
Calif. Residents (800) 848-8008
Local Phone (408) 988-0697

STORE HOURS:
MON-FRI 8:30 A.M.-6:00 P.M.
SAT 10:00 A.M.-3:00 P.M.

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TERMS: For shipping include $2.00 for UPS Ground. $3.00 for UPS Blue Label Air. $10.00 minimum order. Bay Area residents add 6½% Sales Tax. California residents add 6% Sales Tax. We reserve the right to limit quantities and substitute manufacturer. Prices subject to change without notice. Send SASE for complete list.

Circle 151 on inquiry card.

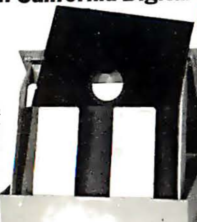
California Digital

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★ FREE ★

Plastic library case supplied with all diskettes purchased from California Digital

$24.95



Private labeled for California Digital by one of the most respected producers of magnetic media. Each diskette is certified double density at 40 tracks. To insure extended media life all diskette are manufactured with a reinforced hub.
Each box of diskettes is supplied with a free plastic library case.
Soft sector CAL-501. Ten sector CAL-510

Ten boxes $22.75 One hundred boxes $21.50



5¼" DISKETTES WITH LIBRARY CASE

$26.50

Your Choice
SCOTCH MEMOREX VERBATIM

Single Side Double Density

	Soft Sector	10 Sector	16 Sector	
SCOTCH	744D-0	744D-10	744D-16	26.50
MEMOREX	3481	3483	3485	26.50
VERBATIM	525-01	525-10	NA	26.50
MAXELL	MD1	MH1-10	MH1-16	29.85
DYSAN	104/1D	107/1D	NA	45.00

Double Side Double Density

SCOTCH	745-0	745-10	745-16	42.50
VERBATIM	550-01	550-10	NA	42.50
MAXELL	MD2-D	MH2-10D	MH2-16D	45.00
DYSAN	104/2D	107/2D	NA	49.50
DYSAN 96	204/2D	NA	NA	59.50

EIGHT INCH DISKETTES

Single Side Single Density

SCOTCH	740-0	29.50
MEMOREX	3060	29.50
DYSAN	3740/1	39.50

Thirty Two Sector

SCOTCH	740-32	29.50

Scotch Head Cleaning Kits 5¼ & 8"	$24.95
Plastic Library Cases 5¼ & 8"	2.95
Diskette Flip Tubs fifty diskettes 5¼"	
Diskette Flip Tubs fifty diskettes 8"	

Single Side Double Density

SCOTCH	741-0	39.00
MEMOREX	3090	35.00
DYSAN	3740/D	57.50

Double side Double Density

SCOTCH	743-0	47.50
MEMOREX	3114	39.50
DYSAN	3740/2D	65.00

Microswitch ASCII KEYBOARD $79



Each keyboard contains 81 high reliability Hall Effect keys. Outputs seven bit parallel ASCII MIC-81SD5 3 Lbs.

$119 WINCHESTER SWITCHING POWER SUPPLY



POWER TWO 5¼" WINCHESTERS OR TWO OF THE NEW HALF HEIGHT 8" DISK DRIVES.
Manufactured exclusively for California Digital by one of the World's largest makers of switching power supplies
Unit supplies 5 volts at 5 Amps and 12 volts at 3 Amps (or) 5 volts at 3 Amps and 24 volts at 3 Amps. Ideal supply for powering two of the new Tandon 8-48 or Shugart SA860. Will accept either 115 60Hz or 230 50Hz CAD-530106 2 Lbs

MEMORY

16K DYNAMIC	2732 EPROM
1.95	**4.95**
4116 150ns.	450ns.
64K DYNAMIC	16K STATIC
6.95	**4.95**
4164 150ns.	6116 200ns.



2764 EPROM SALE $9.95

DYNAMIC MEMORY

		1-31	32+	100+
4027 4K dynamic 250ns	ICM-4027250	1 99	1 85	1 75
4116 150ns 16K	ICM-4116150	1 95	1 85	1 75
4116 200ns 16K	ICM-4116200	1 75	1 65	1 50
4164 150ns 64K 128 refresh	ICM-4164150	6 95	6 50	5 90
41256 150ns 256K	ICM-41256150	Available March83		

STATIC MEMORY

21L02200ns 1K static	ICM-21L02200	1 49	1 29	1 15
21L02 450ns 1K static	ICM-21L02450	1 29	1 15	99
2112 450ns 2K static	ICM-2112450	2 99	285	2 75
2114 300ns 1K x 4	ICM-2114300	1 95	1 85	1 75
4044TMS 450ns 4K x 1	ICM-4044450	3 49	325	2 99
5257300ns 4K x 1	ICM-5257300	2 50	225	1 99
6116 P4200ns 2K x 8	ICM-6116200	495	480	4 65
6116 P3 150ns 2K x 8	ICM-6116150	5 95	5 75	5 60
6167/2167 100ns 16K x 1 (20pin)	ICM-6167100	8 95	8 50	7 90

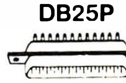
EPROMS

2708 450ns 1K x 8	ICE-2708	4 95	475	455
2716 450ns 2K x 8	ICE-2716	4 95	475	455
2716TMS 450ns Tri-voltage	ICE-2716TMS	7 95	7 65	725
2732 450ns 4K x 8	ICE-2732	4 95	475	4 55
2732 350ns 4K x 8	ICE-2732350	8 50	8 00	7 60
2532 450ns 4K x 8	ICE-2532	1050	990	9 50
2764350ns 8K x 8	ICE-2764	1095	1050	995
27128 350ns 16K x 8	ICE-27128	Available March83		

CONNECTORS



S-100 Gold $2.95



DB25P $2.50

GOLD EDGE CONNECTORS

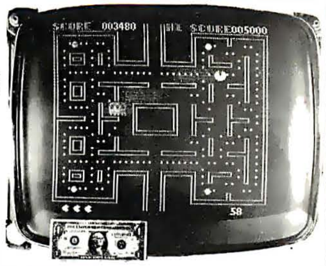
S-100 .125" centers	each	10+
Imsai solder .250" row	$2.95	$2.50
Imsai wire wrap (TI)	3.95	3.50
Sullins Hi-Rel. .250"	4.50	4.00
Sullins Hi-Rel. W/W	5.35	4.90
Sullins /Altair .140"	4.95	4.50
.156" Centers (standard)		
22/44 Kim Eyelet	2.50	2.15
36/72 Digital Group S/T	5.95	5.50
36/72 Digital Group W/W	6.60	6.15
43/86 Motorola 6800S/T	6.60	6.15
43/86 Moto. 6800 W/W	7.00	6.85

INTEGRATED CIRCUIT SOCKETS

	Low Profile each	Low Profile 100+	Wire Wrap each	Wire Wrap 100+
8 pin	$.10	$.09	$.46	$.41
14 pin	.10	.09	.45	.41
16 pin	.12	.11	.50	.45
18 pin	.15	.13	.68	.61
24 pin	.26	.24	.94	.87
40 pin	.42	.40	1.60	1.47

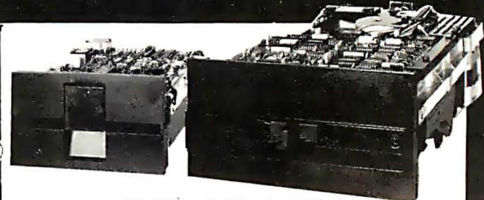
"D" Type	each	10-24	25+
DE9P male	$1.60	$1.40	$1.30
DE9S female	2.25	2.00	1.90
DE hood	1.50	1.35	1.20
DA15P male	2.35	2.15	2.00
DA15S female	3.25	3.10	2.90
DA hood 2/P	1.60	1.35	1.30
DB25P male	2.50	2.35	2.25
DB25S female	3.35	3.15	3.05
DB hood 2/P	1.35	1.15	1.05
DC37P male	4.20	4.00	3.70
DC37S female	6.00	5.75	5.50
DC hood 2/P	2.25	2.00	1.75
DD50P male	5.50	5.10	4.75
DD50S female	9.40	8.60	8.00
DD50 hood 2/P	2.60	2.40	2.10
CENTRONICS			
57-30360	7.95	6.75	5.75
RIBBON CABLE CONNECTORS			
17/34 5" disk	4.85	4.15	3.95
20/40 TRS-80	5.65	5.05	4.70
25/50 8" disk	5.90	5.15	4.90

23" COMPOSITE MONITOR $159



Ideal monitor for classroom demonstrations.

Ever try gathering a classroom of students around a 12" monitor? Here is your opportunity to purchase a 23" high resolution monitor at a reasonable price.
These units accept standard composit video signals generated by most personal computers including the Apple and IBM. Attach it your computer and in second you are shooting down Klingons in wide screen video.
MOT-BW23 35 Lbs. Monitors are open frame and for safety should be enclosed. Wood grained enclosure for above $35.00 additional CAL-ENC23 15 Lbs.



Eight Inch Single Sided

	One	Two	Ten
SHUGART SA801R	$395	385	375
SIEMENS FDD100-8	259	259	225
TANDON 848-1 SLIMLINE	379	369	359
Eight Inch Double Sided			
SHUGART SA851R	525	495	475
QUME DATA TRACK 8	525	495	475
MITSUBISHI M2894-63	485	475	469
OLIVETTI 802/851	369	359	349
TANDON 848-2 SLIMLINE	495	485	475
SHUGART 860 THINLINE	569	549	539
Five Inch Single Sided			
SHUGART SA400	215	209	199
TANDON TM 100-1	209	199	195
Five Inch Double Sided			
SHUGART SA450	349	329	315
TANDON TM 100-2	295	269	259
TANDON 96TPI TM100-4	369	355	350
OLIVETTI 502 ⅔ height	239	225	215
Three Inch Rigid Floppy			
HITACHI-AMDEK	call for pricing		
Five Inch Winchesters			
SEAGATE 506 6 Megabyte	759	725	695
SEAGATE 512 12 Megabyte	995	960	960
TANDON 603SE 14 Megabyte	995	960	895
WESTERN DYNAX removable	995	960	950

Upon request, all drives are supplied with power connectors and manual



$750 *Eight Inch Subsystem*

Two Siemens FDD100-8 disk drives with power supply, 4" exhaust fan complete with all necessary power cables.

Same as above but with:

Shugart 801R	MSD2801	$1195
Shugart 851R	MSD2851	1450
Olivetti 802	CAL2802	$1250
Qume DT8	MSD8DT	1450

ECLIPSE 100 $695



INDUSTRIAL S-100 MAINFRAME

Suitable for hospital and industrial applications. Constructed from 304 brushed stainless steel. Modualar 500 watt toroid power supply provides · 8 volts at 30 Amps and ±16 volts at 4 Amps. Supplied with standard 18 slot Faraday mother board. Auxilary switched AC receptacles. The Eclipse 100 can be either table or rack mounted. Provisions for internally mounting a ten megabyte Winchester disk drive.
The Eclipse 100 is the perfect mainframe to fill the void left by the now defunct TEI Corporation. EPS-100 50 lbs.

VISA
master charge

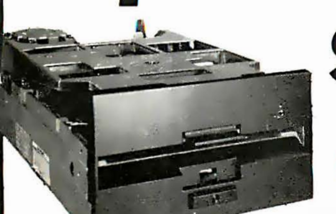
All merchandise sold by California Digital is premium grade.
Shipping: First five pounds $3.00. Each additional $.50.
Foreign orders: 10% shipping. Excess will be refunded.
California residents add 6½% sales tax. COD's discouraged.
Open accounts extended to state supported educational institutions and companies with a "strong" Dun & Bradstreet.
Warehouse: 15608 Inglewood Blvd. Visitors by appointment.

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Super Buy $259



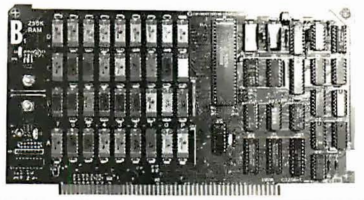
SIEMENS FDD 100-8 8" DISK DRIVE

10 Drives $225 • 100 Drives $209

California Digital has recently participated in the purchase of several thousand Siemens FDD 100-8 floppy disk drives. These units are electronically and physically similar to that of the Shugart 801R disk drive. Any application that will accept an 801R will work with the Siemens FDD 100-8 drive.

All units are new and shipped in factory sealed boxes. Because of the extremely low price we expect a quick sell out. Please reserve your units early. SEA-F1008 17 lbs. Manual and connectors supplied free upon request. Also available: Two drive subsystem supplied in steel enclosure with power supply and fan. $750.00 CAL-2F1008

256K DYNAMIC MEMORY BOARD



$495

- 256 kilobytes of memory using 64K dynamic RAM.
- Over one megabyte of memory using the new 256K dynamic RAM chips.
- Errordetection-trap capability.
- Individual 16K block canbe relocaled toany boundary within a megabyte of RAM.
- 24 bit addressing and phantom mode capability.

The California Digital 256K RAM board represents an outstanding value in S-100 memory technology. Priced slightly above earlier generation 64K dynamic ram boards it gives you these additional features: 256K of memory with parity. Parity error feature can be jumpered to any of the interrupt lines, a status port, ERROR LED, or IEEE-696 ERROR signal. 24 or 16 bit addressing with memory management.

Proper operation with front panel equipped systems, DMA disk controllers, and IEEE-696 Temporary Buss Masters assured with an on the board M1 generator for memory refresh timing. CAS and RAS timing is controlled with tapped digital delay lines for proper operation over the entire operating temperature range.

The board is very recent in design using the National Semiconductor DP-8409 RAM Controller chip. Split termination networks are used on all address lines, CAS line, and RAS lines eliminating the last traces of ringing. The board uses two separate voltage regulators. One for the DRAMs and one for the interface logic increasing the noise immunity of the ram array. Typical power dissipation is 8 watts.

Documentation includes theory of operation, configuration guide, a schematic, and application notes on the use of the memory management options. CAL-256K 2 Lbs

PRINTERS



MATRIX PRINTERS

Okidata 82A serial & parallel 9.5" paper OKI-82A	459.00
Okidata 83A serial & parallel 15" paper OKI-83A	695.00
Okidata 84A parallel only 15" paper OKI-84AP	1,079.00
Okidata 84A serial & parallel 15" paper OKI-84AS	1,219.00
Epson MX80 with graphics and tractor feed EPS-MX80	
Epson MX80FT with graphics, friction & tractor feed EPS-MX80FT	539.00
Epson MX100 with graphics 15" paper EPS-MX100	695.00
NEC 8023A parallel 9.5" paper graphics NEC-8023A	489.00
Anadex 9500A high speed dot matrix printer 15" ADX-9500A	1,279.00
Anadex 9501A 15" paper with graphics ADX-9501A	1,279.00
Texas Instruments 810 serial 15" upper & lower case TEX-810L	1,299.00
Datasouth DS180 high speed 180 char/sec 15" DSI-180	1,295.00
Prowriter 8510 parallel 9.5" PRO-8510P	495.00
Prowriter 8510 serial 9.5" PRO-8510S	639.00
Prowriter II 15" paper PRO-2P	750.00
Printronix P300 high speed printer 300 lines/min PTX-P300	4,500.00
Printronix P600 high speed printer 600 lines/min PTX-P600	6,150.00
IDS prism 80 column, graphics, (non-color) IDS-P80G	1,150.00
IDS prism 132 COLOR with graphics 15" paper IDS-P132CG	1,650.00
Mannesmann Tally 1805 200cps serial MAN-1805	1,650.00

WORD PROCESSING PRINTERS

NEC7710 55 char/sec. thimble, serial only NEC-7710	2,379.00
NEC7730 same as above parallel only NEC-7730	2,379.00
NEC3510 serial 15" NEC-3510	1,775.00
Diablo 620R101 25 cps serial DBL-620	1,270.00
Diablo 630 40 cps serial DBL-630	2,250.00
SmithCorona TP-1 daisy wheel parallel SCMTP1P	659.00
Smith Corona TP-1 daisy wheel serial SCM-TP1S	659.00
Brother HR11 daisy wheel printer parallel BTH-HR1P	855.00
Brother HR11 serial interface BTH-HR1S	895.00
Diablo 630 DBL-630	2,095.00
Starwriter F10 serial PRO-F10S	1,475.00
Starwriter F10 parallel PRO-F10P	1,475.00

MONITORS

Zenith Z121 green phosphor 12" 40/80 column switch ZTH-Z121	115.00
BMC 12A green phosphor 15 Mhz. composit video BMC-12A	88.00
BMC 12EN green phosphor 20 Mhz. high resolution BMC-12EN	139.00
NEC JB1201 green phosphor 18 Mhz composit video NEC-JB1201	169.00
NEC JB1260 green phosphor commercial grade composit NEC-1260	129.00
Motorola 23" open frame blk/white composit video MOT-BW23	159.00
Motorola 12" open frame blk/white requires horz sync & pow MOT-BW12	69.00
Conrac 9" open frame requires horz. sync & power supply CON-BW/9	59.00
(COLOR)	
NEC JC1201 composit color NEC-JC1201	325.00
NEC RGB monitor NEC-1202DM	875.00
BMC 13" Composit video BMC-1400CL	273.00
BMC 13" RGB color monitor BMC-1401RGB	329.00
BMC interface card for Apple II for above RGB BMC-81RGB	149.00
Comrex/Hitachi 13" RGB high res monitor COM-6600	539.00
Comrex/Hitachi 13" Composit color monitor COM-6500	395.00
Amdek color #1 composit video AMD-100	349.00
Amdek color #2 high res. RGB color monitor AMD-200	739.00
Amdek color #3 commercial grade color RGB AMD-300	475.00



Direct Connect MODEMS

Hayes Micromodem 100 S-100 modem HYS-100	319.00
Hayes Smart Model RS232 HYS-232	229.00
Hayes Micromodem II Apple direct connect HYS-MM2	279.00
Hayes Chronograph time & date HYS-CHR232	199.00
Novation Cat acoustic connect NOV-CAT	149.00
Novation D Cat direct connect via handset NOV-DCAT	169.00
Novation 212 Autocat Bell 212A NOV-212	595.00
Novation Auto Cat 103 NOV-AUTO	219.00
Universal 103LP direct connect, line powered UDS-103LP	169.00
Universal 103LPJ direct connect auto answer UDS-103LPJ	209.00
Universal 202 direct connect 1200 baud half duplex UDS-202LP	189.00
Universal 212LP direct connect 1200 baud, full duplex UDS-212LP	450.00
Signalman Mark I direct connect with terminal cable SGL-MK1	89.00

TERMINALS



Ampex Dialogue 80 green screen, two page function keys APX-D80C	795.00
Ampex Dialogue 80 amber screen, two page function keys APX-D80A	795.00
Ampex Dialogue 80 green screen Selectric keyboard APX-D81G	895.00
Ampex Dialogue 81 amber screen Selectric keyboard APX-D81A	895.00
Ampex Touch Term screen command for data entry APX-T80	
Wyse horz & vert split screen, metal case detatch keybd WYS-100	825.00
Televideo 910C emulator TVI-910C	595.00
Televideo 910 Plus block mode TVI-910P	595.00
Televideo 925C detatchable keyboard, 22 function keys TVI-925	795.00
Televideo 950 graphic char split screen 22 functions TVI-950	985.00
IBM 3101-10 detatchable keyboard, green IBM 3101	1,195.00
Zenith Z-19 keyboard ZTH-Z19	765.00
Adds Viewpoint A1 detatchable keyboard ADD-VP1	498.00
Adds Viewpoint A2 xy cursor, green screen ADD-VP2	595.00
Adds Viewpoint A3 emulator ADD-VP3	575.00

APPLE 48K Plus $1089



APPLE BRAND PRODUCTS

APL-48P	Apple Plus 48K RAM	
APL-DSK1	Apple disk with controller card	560.00
APL-DSK2	Apple disk without controller card	495.00

XITEN

XTN-G10	Xiten 10 Megabyte Gallium hard disk	1,995.00
XTN-16K	16K RAM card for Apple II	69.00

RANA SYSTEMS

RAN-APL1	Apple add on disk drive with controller	525.00
RAN-APL2	Apple add on drive without controller	395.00

CALIFORNIA COMPUTER SYSTEMS

CCS-7710	Asynchronous Serial Interface	125.00
CCS-7728	Centronics Parallel Interface	95.00
CCS-7720	Apple Parallel Interface	95.00
CCS-7114	12K Rom/Prom Module	115.00
CCS-7424	Calendar/Clock Module	95.00
CCS-7440	Programmable Timer	95.00
CCS-7811B	Arithmetic Processor for Apple II plus	319.00

MOUNTAIN COMPUTERS, INC.

MTN-CPS	CPS Multifunction Card	169.00
MTN-TCLK	Clock/Calendar	
MTN-STLK	Supertalker SD200	149.00
MTN-ROMF	RomPlus with Keyboard filler	169.00
MTN-ROMRTR	Rom Writer with Eprom socket	145.00
MTN-ADDA	A-D/D-A Converter	269.00
MTN-BSR	X-10 Control Card for BSR system	149.00

MICRO SOFT

MSF-SFTCRD	Microsoft Z-80CPU card	249.00
MSF-16KRAM	Microsoft 16K RAM card	125.00

VISTA

VSA-A800	Vista 8" controller card	489.00
VSA-VIS80	Vista Vision 80	289.00
MCI-CNTRL	MicroSci disk drive controller	89.00

FOURTH DIMENSION

FDN-SPRDRV	Super Drive-35 track Apple add on	329.00

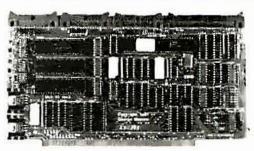
SORRENTO VALLEY ASSOC

SVA-221	Single sided single density controller	360.00
SVA-222	Double sided, single density controller	360.00
SVA-223	Single or double sided, double density	475.00

ADVANCED BUSINESS TECH

ABT-13KEYN	13-Key pad for new Apple	95.00

S-100 BOARDS



16 BIT MICROPROCESSORS

GBT-8687	Godbout 8086/8087 Microprocessor board	495.00
GBT-8687	Godbout 8088/8085 dual 8 bit microprocessor	359.00
SEA-8086	Seattle Computer 16 bit micro two board set	669.00
TEC-8086	Tecmar Computer 16 bit microprocessor	595.00
LOM-8086	Lomas Data Systems LightingOne	call

SINGLE BOARD COMPUTERS

WAV-BLT1	Wavemate Bullet I with floppy 256K (not S-100)	795.00
AMD-Z80	Advanced Micro Digital floppy & 64K	750.00
TEL-FDC1	Teletek FDC1 Single board NEC765 controller	675.00

8 BIT MICROPROCESSORS

GBT-Z80	Godbout Z80 8 bit CPU 24 bit extended address	250.00
CCS-2810	California Computer Z-80 microprocessor	275.00
SDS-SBC200	SD Systems SBC-200 Z-80 microprocessor	275.00
MSM-Z80	Measurement System Z-80 2810 microprocessor	425.00
TAR-Z80	Tarbell Electronics Z-80 with two RS232 ports	395.00

FLOPPY DISK CONTROLLERS

GBT-DSK1	Godbout Disk One double density NEC-765	395.00
MDS-DJ2	Morrow Designs Disk Jockey II with CPM	350.00
MDS-DJ1	Morrow Designs Disk Jockey I single density	225.00
CCS-2422	California Computer 2422 with CPM	339.00
TAR-DDC	Tarbell Electronics double density controller	419.00
TAR-SDC	Tarbell Electronics single density controller	279.00

CPM OPERATING SYSTEM

GBT-CPM22	Godbout CPM 2.2 for Disk One 8 bit operation	160.00
GBT-CPM86D	Godbout CPM 86 for Disk One for use with 8088	265.00
GBT-CPM86	Godbout CPM86 for operation with 8086 board	265.00

HARD DISK CONTROLLER

GBT-DSK2	Godbout Disk II hard disk controller	695.00
GBT-DSK3	Godbout Disk III hard disk controller	
MDS-W506	Morrow Designs Winchester for Seagate 506	495.00
WDI-1000	Western Digital WD-1000 (not S-100)	495.00

EPROM BOARDS

ADS-PB100	Ackerman Digital Prom Blaster 100	275.00
SDS-P100	SD Systems Prom-100 programmer	260.00
SSM-P81	SSM Prom programmer up to 2716	195.00
DGR-P32	Digital Research 32K Eprom read only board	105.00

STATIC MEMORY BOARDS

CAL-S64	California Digital Static 64 8/16 bit (6167)	595.00
GBT-R16	Godbout Ram 16 64K memory 8/16 bit	760.00
GBT-R17	Godbout Ram 17 64K memory 8 bit 24 bit add	395.00
GBT-R20	Godbout Ram 20 32k static memory 4K bound	375.00
GBT-R21	Godbout Ram 21 128K 8/16 bit static memory	995.00
CCS-2116	California Computer 2116 16K static memory	335.00

DYNAMIC MEMORY BOARDS

CAL-D256	California Digital 256K dynamic memory 8 bit	495.00
SDS-EX3	SD Systems Expandoram III 256K dynamic	795.00
CCS-2065	California Computers 2065 64K dynamic	395.00
MSM-DMB64	Measurement Systems DMB6400 (Alpha Micro)	595.00

INTERFACE BOARDS

MDS-SW1	Morrow Designs Switchboard 2 serial 4 parallel	239.00
MDS-MLT1	Morrow Designs Multiboard 3 serial 2 parallel	275.00
[illegible]	Godbout Interfacer I 2 serial ports	199.00
[illegible]	Godbout Interfacer II 1 serial 3 parallel	199.00
[illegible]	Godbout Interfacer III with 5 serial ports	495.00
[illegible]	Godbout Interfacer III with 8 serial ports	585.00
[illegible]	Godbout Interfacer IV 3 serial 2 parallel	295.00
CCS-2710	California Computer 4 port serial interface	295.00
[illegible]	California Computer 2 serial 2 parallel	295.00
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HYS-M100	DC Hayes Micromodem S-100 FCC approved	325.00
ADS-N100	Ackerman Digital Noisemaker with Votrax module	119.00
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[illegible]	[illegible]	965.00
[illegible]	Godbout Spectrum 100 color video board	399.00
[illegible]	Tecmar A-D 12 bit accuracy 16 channel	485.00
GBT-SYS1	Godbout System support board	350.00
GBT-SYS9511	Godbout System Support with 8231 9511 math chip	539.00
[illegible]	[illegible] board with test probe	79.00
[illegible]	[illegible] Opto Isolator controls 8 channels	179.00
[illegible]	Ackerman Digital Kluge prototype board	149.00
[illegible]	I-O Technology wire wrap prototype board	49.00
[illegible]	[illegible] Electronics Wire wrap proto board	25.00
[illegible]	[illegible] Electronics General purpose solder	25.00
[illegible]	California Digital 18 slot motherboard	35.00

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STATIC RAMS

2101	256 x 4 (450ns)	1.95
5101	256 x 4 (450ns) (cmos)	3.95
2102-1	1024 x 1 (450ns)	.89
2102L-4	1024 x 1 (450ns) (LP)	1.29
2102L-2	1024 x 1 (250ns) (LP)	1.69
2111	256 x 4 (450ns)	2.99
2112	256 x 4 (450ns)	2.99
2114	1024 x 4 (450ns)	8/14.95
2114L-4	1024 x 4 (450ns) (LP)	8/15.25
2114L-3	1024 x 4 (300ns) (LP)	8/15.45
2114L-2	1024 x 4 (200ns) (LP)	8/15.95
2147	4096 x 1 (55ns)	4.95
TMS4044-4	4096 x 1 (450ns)	3.49
TMS4044-3	4096 x 1 (300ns)	3.99
TMS4044-2	4096 x 1 (200ns)	4.49
MK4118	1024 x 8 (250ns)	9.95
TMM2016-200	2048 x 8 (200ns)	4.15
TMM2016-150	2048 x 8 (150ns)	4.95
TMM2016-100	2048 x 8 (100ns)	6.15
HM6116-4	2048 x 8 (200ns) (cmos)	4.95
HM6116-3	2048 x 8 (150ns) (cmos)	5.95
HM6116-2	2048 x 8 (120ns) (cmos)	8.95
HM6116LP-4	2048 x 8 (200ns) (cmos)(LP)	6.95
HM6116LP-3	2048 x 8 (150ns) (cmos)(LP)	8.95
HM6116LP-2	2048 x 8 (120ns) (cmos)(LP)	10.95
Z-6132	4096 x 8 (300ns) (Qstat)	34.95

LP = Low Power Qstat = Quasi-Static

DYNAMIC RAMS

TMS4027	4096 x 1 (250ns)	1.99
UPD411	4096 x 1 (300ns)	3.00
MM5280	4096 x 1 (300ns)	3.00
MK4108	8192 x 1 (200ns)	1.95
MM5298	8192 x 1 (250ns)	1.85
4116-300	16384 x 1 (300ns)	8/11.75
4116-250	16384 x 1 (250ns)	8/11.95
4116-200	16384 x 1 (200ns)	8/13.95
4116-150	16384 x 1 (150ns)	8/15.95
4116-120	16384 x 1 (120ns)	8/29.95
2118	16384 x 1 (150ns) (5v)	4.95
4164-200	65536 x 1 (200ns) (5v)	6.25
4164-150	65536 x 1 (150ns) (5v)	7.25

5V = single 5 volt supply

EPROMS

1702	256 x 8 (1us)	4.50
2708	1024 x 8 (450ns)	3.95
2758	1024 x 8 (450ns)(5v)	5.95
2716	2048 x 8 (450ns)(5v)	3.95
2716-1	2048 x 8 (350ns)(5v)	6.25
TMS2516	2048 x 8 (450ns)(5v)	5.50
TMS2716	2048 x 8 (450ns)	7.95
TMS2532	4096 x 8 (450ns)(5v)	7.95
2732	4096 x 8 (450ns)(5v)	4.95
2732-250	4096 x 8 (250ns)(5v)	12.95
2732-200	4096 x 8 (200ns)(5v)	16.95
2764	8192 x 8 (450ns)(5v)	16.95
2764-250	8192 x 8 (250ns)(5v)	18.95
2764-200	8192 x 8 (200ns)(5v)	24.95
TMS2564	8192 x 8 (450ns)(5v)	24.95
MC68764	8192 x 8 (450ns)(5v)(24 pin)	39.95

5v = Single 5 Volt Supply

EPROM ERASERS

	Timer	Capacity Chip	Intensity (uW/Cm²)	
PE-14		6	5,200	83.00
PE-14T	X	6	5,200	119.00
PE-24T	X	9	6,700	175.00
PL-265T	X	20	6,700	255.00
PR-125T	X	16	15,000	349.00
PR-320	X	32	15,000	595.00

DISC CONTROLLERS

1771	16.95
1791	29.95
1793	38.95
1795	54.95
1797	54.95
6843	34.95
8272	39.95
UPD765	39.95
1691	18.95
2143	18.95

INTERFACE

8T26	1.69
8T28	2.49
8T95	.99
8T96	.99
8T97	.99
8T98	.99
DM8131	2.95
DP8304	2.29
DS8835	1.99
DS8836	.99

MISC.

3242	7.95
3341	4.95
MC3470	4.95
MC3480	9.00
11C90	13.95
95H90	7.95
2513-001 UP	9.95
2513-002 LOW	9.95

SOUND CHIPS

76477	3.95
76489	8.95
AY3-8910	12.95
MC3340	1.49

CRT CONTROLLERS

6845	14.95
68B45	35.95
HD46505SP	15.95
6847	12.25
MC1372	6.95
68047	24.95
8275	29.95
7220	99.95
CRT5027	39.95
CRT5037	49.95
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MC14411	11.95
BR1941	11.95
4702	12.95
CDM5016	16.95
COM8116	10.95
MM5307	10.95

UARTS

AY3-1014	6.95
AY5-1013	3.95
AY3-1015	6.95
PT1472	9.95
TR1602	3.95
2350	9.95
2651	8.95
TMS6011	5.95
IM6402	7.95
IM6403	8.95
INS8250	14.95

KEYBOARD CHIPS

AY5-2376	11.95
AY5-3600	11.95

CLOCK CIRCUITS

MM5314	4.95
MM5369	3.95
MM5375	4.95
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MM58174	11.95
MSM5832	6.95

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Z80-DMA	17.50
Z80-PIO	5.75
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4.0 Mhz

Z80A-CPU	6.00
Z80A-CTC	8.65
Z80A-DART	18.75
Z80A-DMA	27.50
Z80A-PIO	6.00
Z80A-SIO/0	22.50
Z80A-SIO/1	22.50
Z80A-SIO/2	22.50
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Z80B-PIO	15.50

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Z8671	39.95

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2.097152	3.95
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3.2768	3.95
3.579535	3.95
4.0	3.95
5.0	3.95
5.0688	3.95
5.185	3.95
5.7143	3.95
6.0	3.95
6.144	3.95
6.5536	3.95
8.0	3.95
10.738635	3.95
14.31818	3.95
15.0	3.95
16.0	3.95
17.430	3.95
18.0	3.95
18.432	3.95
20.0	3.95
22.1184	3.95
32.0	3.95

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ADC0800	15.55
ADC0804	3.49
ADC0809	4.49
ADC0817	9.95
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DAC0806	1.95
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DAC1020	8.25
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8085A-2	11.95
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8088	39.95
8089	89.95
8155	7.95
8156	8.95
8185	29.95
8185-2	39.95
8741	39.95
8748	29.95
8755	32.00

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8202	29.95
8203	39.95
8205	3.50
8212	1.80
8214	3.85
8216	1.75
8224	2.25
8226	1.80
8228	3.49
8237	19.95
8238	4.49
8243	4.45
8250	10.95
8251	4.49
8253	6.95
8253-5	7.95
8255	4.49
8255-5	5.25
8257	7.95
8257-5	8.95
8259	6.90
8259-5	7.50
8271	39.95
8272	39.95
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8279-5	10.00
8282	6.50
8283	6.50
8284	5.50
8286	6.50
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8289	49.95

FUNCTION GENERATORS

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LM566	1.49
XR2206	3.75
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INTERSIL

ICL7103	9.50
ICL7106	9.95
ICL7107	12.95
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6800

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6809	12.95
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6820	4.95
6821	3.25
6828	14.95
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6843	34.95
6844	25.95
6845	14.95
6847	12.25
6850	3.45
6852	5.75
6860	9.95
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6875	6.95
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68488	19.95

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68B09	29.95
68B10	7.95
68B21	12.95
68B45	35.95
68B50	12.95

68B00 = 2 MHZ

6500

1 MHZ

6502	5.95
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6532	11.25
6545	22.50
6551	11.85

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6551A	12.95

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74LS02	.25	74LS91	.89	74LS173	.69	74LS352	1.29
74LS03	.25	74LS92	.55	74LS174	.55	74LS353	1.29
74LS04	.24	74LS93	.55	74LS175	.55	74LS363	1.35
74LS05	.25	74LS95	.75	74LS181	2.15	74LS364	1.95
74LS08	.28	74LS96	.89	74LS189	8.95	74LS365	.49
74LS09	.29	74LS107	.39	74LS190	.89	74LS366	.49
74LS10	.25	74LS109	.39	74LS191	.89	74LS367	.45
74LS11	.35	74LS112	.39	74LS192	.79	74LS368	.45
74LS12	.35	74LS113	.39	74LS193	.79	74LS373	.99
74LS13	.45	74LS114	.39	74LS194	.69	74LS374	.99
74LS14	.59	74LS122	.45	74LS195	.69	74LS377	1.39
74LS15	.35	74LS123	.79	74LS196	.79	74LS378	1.18
74LS20	.25	74LS124	2.90	74LS197	.79	74LS379	1.35
74LS21	.29	74LS125	.49	74LS221	.89	74LS385	1.90
74LS22	.25	74LS126	.49	74LS240	.95	74LS386	.45
74LS26	.29	74LS132	.59	74LS241	.99	74LS390	1.19
74LS27	.29	74LS133	.59	74LS242	.99	74LS393	1.19
74LS28	.35	74LS136	.39	74LS243	.99	74LS395	1.19
74LS30	.25	74LS137	.99	74LS244	.99	74LS399	1.49
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74LS42	.49	74LS151	.55	74LS253	.59	74LS669	1.89
74LS47	.75	74LS153	.55	74LS257	.59	74LS670	1.49
74LS48	.75	74LS154	1.90	74LS258	.59	74LS674	9.65
74LS49	.75	74LS155	.69	74LS259	2.75	74LS682	3.20
74LS51	.25	74LS156	.69	74LS260	.59	74LS683	3.20
74LS54	.29	74LS157	.65	74LS266	.55	74LS684	3.20
74LS55	.29	74LS158	.59	74LS273	1.49	74LS685	3.20
74LS63	1.25	74LS160	.69	74LS275	3.35	74LS688	2.40
74LS73	.39	74LS161	.65	74LS279	.49	74LS689	3.20
74LS74	.35	74LS162	.69	74LS280	1.98	74LS783	24.95
74LS75	.39	74LS163	.65	74LS283	.69	81LS95	1.49
74LS76	.39	74LS164	.69	74LS290	.89	81LS96	1.49
74LS78	.49	74LS165	.95	74LS293	.89	81LS97	1.49
74LS83	.60	74LS166	1.95	74LS295	.99	81LS98	1.49
74LS85	.69	74LS168	1.75	74LS298	.89	25LS2521	2.80
				74LS299	1.75	25LS2569	4.25

IC SOCKETS

	1-99	100
8 pin ST	.13	.11
14 pin ST	.15	.12
16 pin ST	.17	.13
18 pin ST	.20	.18
20 pin ST	.29	.27
22 pin ST	.30	.27
24 pin ST	.30	.27
28 pin ST	.40	.32
40 pin ST	.49	.39
64 pin ST	4.25	call
ST = SOLDERTAIL		
8 pin WW	.59	.49
14 pin WW	.69	.52
16 pin WW	.69	.58
18 pin WW	.99	.90
20 pin WW	1.09	.98
22 pin WW	1.39	1.28
24 pin WW	1.49	1.35
28 pin WW	1.69	1.49
40 pin WW	1.99	1.80
WW = WIREWRAP		
16 pin ZIF	6.75	call
24 pin ZIF	9.95	call
28 pin ZIF	10.95	call

ZIF = TEXTOOL (Zero Insertion Force)

CONNECTORS

RS232 MALE	2.95
RS232 FEMALE	3.50
RS232 FEMALE RIGHT ANGLE	5.25
RS232 HOOD	1.25
S-100 ST	3.95
S-100 WW	4.95

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4 POSITION	.85
5 POSITION	.90
6 POSITION	.90
7 POSITION	.95
8 POSITION	.95

7400

7400	.19	74132	.45
7401	.19	74136	.50
7402	.19	74141	.65
7403	.19	74142	2.95
7404	.19	74143	2.95
7405	.25	74145	.60
7406	.29	74147	1.75
7407	.29	74148	1.20
7408	.24	74150	1.35
7409	.19	74151	.55
7410	.19	74152	.65
7411	.25	74153	.55
7412	.30	74154	1.25
7413	.35	74155	.75
7414	.49	74156	.65
7416	.25	74157	.55
7417	.25	74159	1.65
7420	.19	74160	.85
7421	.35	74161	.69
7422	.35	74162	.85
7423	.29	74163	.69
7425	.29	74164	.85
7426	.29	74165	.85
7427	.29	74166	1.00
7428	.45	74167	2.95
7430	.19	74170	1.65
7432	.29	74172	5.95
7433	.45	74173	.75
7437	.29	74174	.89
7438	.29	74175	.89
7440	.19	74176	.89
7442	.49	74177	.75
7443	.65	74178	1.15
7444	.69	74179	1.75
7445	.69	74180	.75
7446	.69	74181	2.25
7447	.69	74182	.75
7448	.69	74184	2.00
7450	.19	74185	2.00
7451	.23	74186	18.50
7453	.23	74190	1.15
7454	.23	74191	1.15
7460	.23	74192	.79
7470	.35	74193	.79
7472	.29	74194	.85
7473	.34	74195	.85
7474	.33	74196	.79
7475	.45	74197	.75
7476	.35	74198	1.35
7480	.59	74199	1.35
7481	1.10	74221	1.35
7482	.95	74246	1.35
7483	.50	74247	1.25
7485	.59	74248	1.85
7486	.35	74249	1.95
7489	2.15	74251	.75
7490	.35	74259	2.25
7491	.40	74265	1.35
7492	.50	74273	1.95
7493	.35	74276	1.25
7494	.65	74279	.75
7495	.55	74283	2.00
7496	.70	74284	3.75
7497	2.75	74285	3.75
74100	1.75	74290	.95
74107	.30	74293	.75
74109	.45	74298	.85
74110	.45	74351	2.25
74111	.55	74365	.65
74116	1.55	74366	.65
74120	1.20	74367	.65
74121	.29	74368	.65
74122	.45	74376	2.20
74123	.49	74390	1.75
74125	.45	74393	1.35
74126	.45	74425	3.15
74128	.55	74426	.85
		74490	2.55

CMOS

4000	.29	4527	1.95
4001	.25	4528	1.19
4002	.25	4531	.95
4006	.89	4532	1.95
4007	.29	4538	1.95
4008	.95	4539	1.95
4009	.39	4541	2.64
4010	.45	4543	1.19
4011	.25	4553	5.79
4012	.25	4555	.95
4013	.38	4556	.95
4014	.79	4581	1.95
4015	.39	4582	1.95
4016	.39	4584	.75
4017	.69	4585	.75
4018	.79	4702	12.95
4019	.39	74C00	.35
4020	.75	74C02	.35
4021	.79	74C04	.35
4022	.79	74C08	.35
4023	.29	74C10	.35
4024	.65	74C14	.59
4025	.29	74C20	.35
4026	1.65	74C30	.35
4027	.45	74C32	.39
4028	.69	74C42	1.29
4029	.79	74C48	1.99
4030	.39	74C73	.65
4034	1.95	74C74	.65
4035	.85	74C76	.80
4040	.75	74C83	1.95
4041	.75	74C85	1.95
4042	.69	74C86	.39
4043	.85	74C89	4.50
4044	.79	74C90	1.19
4046	.85	74C93	1.75
4047	.95	74C95	.99
4049	.35	74C107	.89
4050	.35	74C150	5.75
4051	.79	74C151	2.25
4053	.79	74C154	3.25
4060	.89	74C157	1.75
4066	.39	74C160	1.19
4068	.39	74C161	1.19
4069	.29	74C162	1.19
4070	.35	74C163	1.19
4071	.29	74C164	1.39
4072	.29	74C165	2.00
4073	.29	74C173	.79
4075	.29	74C174	1.19
4076	.79	74C175	1.19
4078	.29	74C192	1.49
4081	.29	74C193	1.49
4082	.29	74C195	1.39
4085	.95	74C200	5.75
4086	.95	74C221	1.75
4093	.49	74C373	2.45
4098	2.49	74C374	2.45
4099	1.95	74C901	.39
14409	12.95	74C902	.85
14410	12.95	74C903	.85
14411	11.95	74C905	10.95
14412	12.95	74C906	.95
14419	7.95	74C907	1.00
14433	4.18	74C908	2.00
4502	.95	74C909	2.75
4503	.65	74C911	8.95
4508	1.95	74C912	8.95
4510	.85	74C914	1.95
4511	.85	74C915	1.19
4512	.85	74C918	2.75
4514	1.25	74C920	17.95
4515	1.79	74C921	15.95
4516	1.55	74C922	4.49
4518	.89	74C923	4.95
4519	.39	74C925	5.95
4520	.79	74C926	7.95
4522	1.25	74C928	7.95
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74S02	.35	74S168	3.95
74S03	.35	74S169	3.95
74S04	.35	74S174	.95
74S05	.35	74S175	.95
74S08	.35	74S181	3.95
74S09	.40	74S182	2.95
74S10	.35	74S188	1.95
74S11	.35	74S189	6.95
74S15	.35	74S194	1.49
74S20	.35	74S195	1.49
74S22	.35	74S196	1.49
74S30	.35	74S197	1.49
74S32	.40	74S201	6.95
74S37	.88	74S225	7.95
74S38	.85	74S240	2.20
74S40	.35	74S241	2.20
74S51	.35	74S244	2.20
74S64	.40	74S251	.95
74S65	.40	74S253	.95
74S74	.50	74S257	.95
74S85	1.99	74S258	.95
74S86	.50	74S260	.79
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74S114	.55	74S280	1.95
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FND-500 (503)	.5"	CC	1.49
FND-507 (510)	.5"	CA	1.49

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Jumbo Green	.18	.15
Jumbo Yellow	.18	.15

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PN2907	PNP SWITCH	TO-92	10/1.25	100/10.99
2N2222	NPN SWITCH	TO-18	.25	50/10.99
2N2907	PNP SWITCH	TO-18	.25	50/10.99
2N3055	NPN POWER	TO-3	.79	10/6.99
3055T	NPN POWER	TO-220	.69	10/5.99
2N3904	NPN SWITCH	TO-92	10/1.00	100/8.99
2N3906	NPN SWITCH	TO-92	10/1.00	100/8.99
IN4148 (IN914)	SWITCHING		25/1.00	1000/35.00
IN4004	RECTIFIER		10/1.00	100/8.99

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LM301	.34	LM348	.99	NE564	2.95	LM1496	.85
LM301H	.79	LM350K	4.95	LM565	.99	LM1558H	3.10
LM307	.45	LM350T	4.60	LM566	1.49	LM1800	2.37
LM308	.69	LM358	.69	LM567	.89	LM1812	8.25
LM308H	1.15	LM359	1.79	NE570	3.95	LM1830	3.50
LM309H	1.95	LM376	3.75	NE571	2.95	LM1871	5.49
LM309K	1.25	LM377	1.95	NE592	2.75	LM1872	5.49
LM310	1.75	LM378	2.50	LM703	.89	LM1877	3.25
LM311	.64	LM379	4.50	LM709	.59	LM1889	1.95
LM311H	.89	LM380	.89	LM710	.75	LM1896	1.75
LM312H	1.75	LM380N-8	1.10	LM711	.79	LM2877	2.05
LM317K	3.95	LM381	1.60	LM723	.49	LM2878	2.25
LM317T	1.19	LM382	1.60	LM723H	.55	LM2900	.85
LM318	1.49	LM383	1.95	LM733	.98	LM2901	1.00
LM318H	1.59	LM384	1.95	LM741	.35	LM3900	.59
LM319H	1.90	LM386	.89	LM741N-14	.35	LM3905	1.25
LM319	1.25	LM387	1.40	LM741H	.40	LM3909	.98
LM320 (see 7900)		LM389	1.35	LM747	.69	LM3911	2.25
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LM329	.65	LM399H	5.00	LM1310	1.49	MC4024	3.95
LM331	3.95	NE531	2.95	MC1330	1.69	MC4044	4.50
LM334	1.19	NE536	6.00	MC1349	1.89	RC4136	1.25
LM335	1.40	NE555	.34	MC1350	1.19	RC4151	3.95
LM336	1.75	NE556	.65	MC1358	1.69	LM4250	1.75
LM337K	3.95	NE558	1.50	MC1372	6.95	LM4500	3.25
LM337T	1.95	NE555	.34	LM1414	1.59	LM13080	1.29
LM338K	6.95	NE556	.65	LM1458	.59	LM13600	1.49
LM339	.99	NE558	1.50	LM1488	.69	LM13700	1.49
LM340 (see 7800)		NE561	24.95	LM1489	.69		

H = TO-5 CAN T = TO-220 K = TO-3

RCA

CA 3023	2.75	CA 3082	1.65
CA 3039	1.29	CA 3083	1.55
CA 3046	1.25	CA 3086	.80
CA 3059	2.90	CA 3089	2.99
CA 3060	2.90	CA 3096	3.49
CA 3065	1.75	CA 3130	1.30
CA 3080	1.10	CA 3140	1.15
CA 3081	1.65	CA 3146	1.85
		CA 3160	1.19

TI

TL494	4.20	75365	1.95
TL496	1.65	75450	.59
TL497	3.25	75451	.39
75107	1.49	75452	.39
75110	1.95	75453	.39
75150	1.95	75454	.39
75154	1.95	75491	.79
75188	1.25	75492	.79
75189	1.25	75493	.89
		75494	.89

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TL071	.79	TL084	2.19
TL072	1.19	LF347	2.19
TL074	2.19	LF351	.60
TL081	.79	LF353	1.00
TL082	1.19	LF355	1.10
TL083	1.19	LF356	1.10
		LF357	1.40

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7808T	.89	7908T	.99
7812T	.89	7912T	.99
7815T	.89	7915T	.99
7824T	.89	7924T	.99
7805K	1.39	7905K	1.49
7812K	1.39	7912K	1.49
7815K	1.39	7915K	1.49
7824K	1.39	7924K	1.49
78L05	.69	79L05	.79
78L12	.69	79L12	.79
78L15	.69	79L15	.79
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T = TO-220 K = TO-3
L = TO-92

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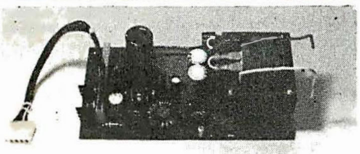
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CCS 16K Static Ram Module	259.00
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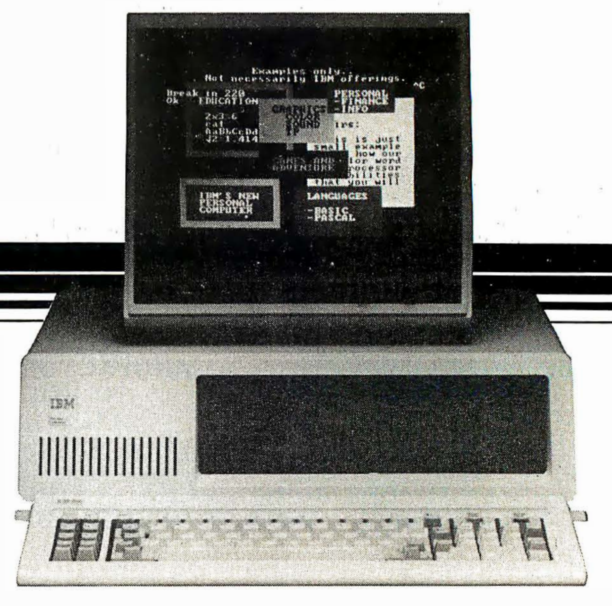
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BUSINESS

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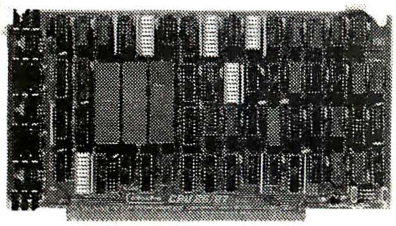
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16 bit 8 or 10 MHz 8086 CPU with sockets for 8087 and 80130

Part No.	Description	List Price	Our Price
BAGBT186A	A&T 8MHz 8086 only	$695.00	$625.00
BAGBT186C	CSC 10MHz 8086 only	$850.00	$765.00
BAGBT186AB7	A&T with 8087 option	$995.00	$925.00
BAGBT186CB7	CSC with 8087 option*	$1150.00	$1065.00

**8087 Limits clock speed to 5MHz*

(816) DUAL PROCESSOR 8085-8088

6 or 8 MHz provides true 16 Bit Power with a standard 8 bit S-100 bus

BAGBT1612A	A&T 6MHz	$425.00	$399.00
BAGBT1612C	CSC 6/8 MHz	$525.00	$498.00

68K - 68000 16 BIT CPU

16 bit 8 or 10 MHz on-board sockets for 2716, 2732, or 2764 EPROMs for up to 8K x 16 of memory

BAGBT184A	A&T 8MHz	$695.00	$625.00
BAGBT184C	CSC 10MHz	$850.00	$765.00

FORTH OPERATING SYSTEM FOR 68K CPU

Requires a DISK 1, 64K of CompuPro memory, and an INTERFACER 3 or 4.

BAGBT68KOS	FORTH operating syst m	$200.00

CPUZ - Z80B CPU NOW 6MHz!

3/6 MHz Z80B CPU with 24 Bit Addressing. FASTEST Z80 CPU AVAILABLE!

BAGBT160A	3/6 MHz A&T	$295.00	$280.00
BAGBT160C	3/6 MHz CSC	$395.00	$375.00



DISK CONTROLLERS

DISK 1 FLOPPY CONTROLLER

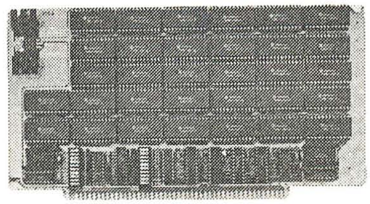
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**With purchase of 2 or more 8' Disk Drives and one Disk 1 Controller*

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BAGBTCPM80*	CP/M 2.2 for Z80/8085 w/manuals & BIOS 8" S/D disk		$175.00
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BAGBT171A	Assembled & Tested	$495.00	$450.00
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Fast DMA 2 board set. controls 4 Shugart 4000 series or Fujitsu 2300 type drives. Includes CP/M 2.2'

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RAM 17 - 64K CMOS STATIC RAM

12 MHz, RAM 17, 2 Watt, DMA Compatible 24 Bit Addressing

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BAGBT175A64	64K A&T 12MHz	$599.00	$550.00
BAGBT175C64	64K CSC 12MHz	$699.00	$650.00

RAM 16 - 32K x 16 BIT CMOS STATIC RAM

8 and/or 16 Bit
(816) 12 MHz, RAM 16, 32K x 16 or 64K x 8 IEEE/696 16 Bit 2 Watt, 24 Bit Addressing

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BAGBT180A	64K A&T 12MHz	$650.00	$599.00
BAGBT180C	64K CSC 12MHz	$750.00	$699.00

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(816) RAM 21 12MHz, 128K x 8 or 64K x 16 IEEE/696 8 or 16 Bit, 1.2 Amps, 24 Bit Addressing

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BAGBT190C	128K CSC	$1450.00	$1375.00

M-DRIVE SOLID STATE DISK DRIVE, 3500% FASTER!!

Not really, but the next best thing for CompuPro 8085/88 Users. Call for Details on M-Drive. M-Drive requires a 6MHz CPU8085/88 dual processor. Disk 1 DMA disk controller and System Support 1 Multifunction Board.

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BAGBTMD128KC	128K of CSC memory & M-Drive Software	$1398.00
BAGBTMD256KA	256K of A&T memory & M-Drive Software	$2395.00
BAGBTMD256KC	256 of CSC memory & M-Drive Software	$2795.00

M-DRIVE/H HARDWARE LOGICAL DISK SYSTEM

Interfaces through two I/O ports, and runs at 10M Hz. IEEE 696 compatible. Requires any CompuPro CPU and a Disk 1. Each board contains 512K of fast, low power (900mA) RAM, with parity checking.

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STATIC MEMORY BOARDS

RAM 20 - 32K STATIC RAM

RAM 20 10MHz, 4K byte block disable, bank select or 24 bit addressing available 8, 16, 24 or 32K

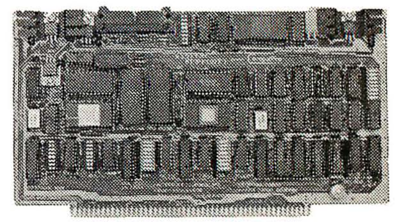
BAGBT164AA8	8K A&T	$210.00	$190.00
BAGBT164AC8	8K CSC	$280.00	$260.00
BAGBT164AA16	16K A&T	$285.00	$260.00
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BAGBT164AC24	24K CSC	$425.00	$385.00
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BAGBT162CM1	CSC w/8231 Math Chip		$655.00
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BAGBT162CM2	CSC w/8232 Math Chip		$655.00

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	With 16K RAM		
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BAGBT166C16	CSC	$749.00	$675.00

INTERFACER 1

Two Serial I/O

BAGBT133A	Assembled & Tested	$249.00	$219.00
BAGBT133C	CSC	$324.00	$298.00

INTERFACER 2

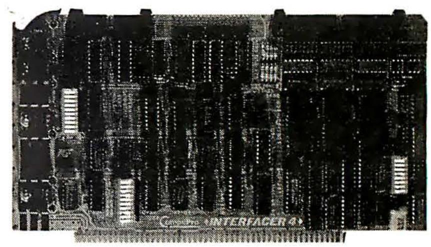
Three parallel, one serial I/O board

BAGBT150A	Assembled & Tested	$249.00	$219.00
BAGBT150C	CSC	$324.00	$298.00

INTERFACER 3

Eight-channel multi-user serial I/O board

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BAGBT174BC	CSC 200 hr. 8 port	$849.00	$775.00
BAGBT1745A	Assembled & Tested	$599.00	$559.00
BAGBT1745C	CSC 200 hr. 5 port	$699.00	$629.00



INTERFACER 4

Three Serial, 1 Parallel, 1 Centronics Parallel

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BAGBT187C	CSC	$495.00	$450.00

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BAGBT154A	A&T 12 slot, 3 lbs.	$175.00	$155.00
BAGBT154C	CSC 12 slot, 3 lbs.	$240.00	$220.00
BAGBT155A	A&T 20 slot, 4 lbs.	$265.00	$235.00
BAGBT155C	CSC 20 slot, 4 lbs.	$340.00	$310.00

Circle 328 on inquiry card.

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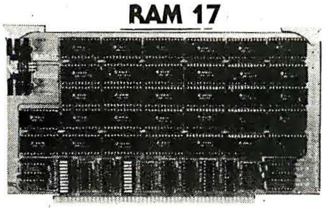
S-100 STATIC RAM - ULTRA LOW POWER - ONLY 2 WATTS

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UNBELIEVABLE! While the rest of the industry struggles to attain 6MHz, CompuPro has effortlessly jumped from 10 to 12MHz. The power consumption (400mA; 2 Watts) is still the lowest in spite of running nearly twice as fast. Priority One Electronics has purchased the remainder of CompuPro's 10MHz boards and are offering them at these unprecedented prices.

RAM 17

- Extremely low power consumption (2 watts typical)
- Flawlessly handles any DMA device per IEEE 696 specifications
- Single +5 Volt operation (requires no other supply voltages)
- Switch-Selectable choice of 24 address lines conforming to IEEE 696/S-100 extended addressing
- 2K windows, individually selectable at E000, E800, F000, and F800 permits use with older memory-mapped disk controllers or ROM (i.e., Morrow, NorthStar)
- Any 16K block may be disabled; dip switch selectable 2K disable from XXE000 - FFFF in 2K increments
- Switch Selectable PHANTOM disable



SALE PRICE: $319.00 ea.

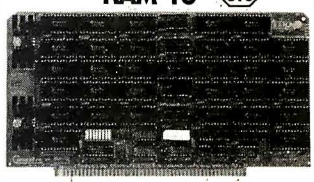
List Price: $599.00

***2 or More: $299.00 ea.**

BAGBTRAM17 Assembled & Tested

RAM 16 (816)

- Board addressable as one 64K x 8 or 32K x 16 block; DIP switch selectable on any 64K boundary
- Extremely low power consumption (2 watts typical)
- Meets or exceeds all IEEE 696/S-100 specifications
- Flawlessly handles any DMA device per IEEE 696 specifications
- Single +5 Volt operation (requires no other supply voltages)
- 24 bit addressing; conforms to IEEE 696 specifications
- 8 or 16 bit data transfer dependant on SXTRQ. Conforms with IEEE 696 timing requirements for XTRQ and SIXTN



SALE PRICE: $349.00 ea.

List Price: $650.00

2 or More: $325.00 ea.

BAGBTRAM16 Assembled & Tested

CompuPro™

NEW 16 BIT 12 USER SYSTEM 816/D



SAVE OVER $4000.00 ON SYSTEM & TERMINAL!

The **System 816/D** is a high performance, multi-user, multi-tasking 16-bit system, with the power needed for involved applications such as software development. This is the preferred system for business, industrial or scientific environments. In addition, the **816/D** delivers spooling (simultaneous printing and editing) to further increase productivity.

- 10MHz 16 bit 8086 CPU with 80130 operating system firmware component
- 512K bytes of low power RAM
- 1 megabyte of M-DRIVE/H high speed solid state logical disk system
- Fast DMA floppy controller with 2 double sided 8" disk drives; 2.4 megabytes of storage
- 20 slot desk top S-100 enclosure
- 12 serial interfaces
- 1 parallel, 1 Centronics parallel interface

Software: CP/M-86, MP/M-86, SuperCalc

Convenience features: clock/calendar; interrupt controllers; interval timers, and co-processor and Operating System Firmware option.

This **System 816/D** is priced at $13,995.00, a savings of over $3,000 if all of the components were purchased separately.

Part No.	Description	Price
BAGBTSYS816DDA	Multiuser 16 bit desk top system A&T	$13,995.00
BAGBTSYS816DDC	Multiuser 16 bit desk top system CSC	$15,995.00
BAGBTSYS816DDA21	Same as above with RAM 21s, A&T	$14,395.00
BAGBTSYS816DDC21	Same as above with RAM 21s, CSC	$16,395.00

OASIS 16 SYSTEM 816/016

All the hardware mentioned with the System 816/D with the OASIS 16 Operating System and utilities instead of CP/M-86, MP/M-86, and SuperCalc.

Part No.	Description	Price
BAGBTSYS816DDA	Multiuser 16 bit desk top system A&T	$13,995.00
BAGBTSYS816DDC	Multiuser 16 bit desk top system CSC	$15,995.00
BAGBTSYS816DDA21	Same as above with RAM 21s, A&T	$14,395.00
BAGBTSYS816DDC21	Same as above with RAM 21s, CSC	$16,395.00

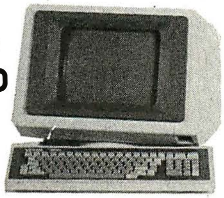
VISUAL 330 $1.00!!

With the purchase of any CompuPro System D

AN ADDITIONAL SAVINGS VALUE OF: $1049.00

VSL330GN Specifications in column at right

VISUAL 330 AND 300



SORRY TELEVIDEO, THIS IS THE NEW STANDARD

The microprocessor-based VISUAL 330 combines VISUAL ergonomic elegance with selectable emulations of the DEC VT52®, Data General D200, Lear Siegler ADM-3A, and Hazeltine 1500 terminals.

Specifications	VISUAL 330	VISUAL 300	TeleVideo 950
ANSI X3.64 Specified	NO	STD	NO
Solid State Keyboard	STD	STD	NO
Programmable Non-volatile Function Keys	STD	STD	NO
Video Attributes Require No Display Space	STD	STD	NO
Smooth Scroll, Slow Scroll and Jump Scroll	STD	STD	NO
Non Volatile Set-up Modes, "Menu" Style	STD	STD	NO
Block Graphics	STD	STD	NO
Sculptured Keycaps, Matted for Low Glare	STD	STD	NO
Programmable Non Volatile Columnar Tabbing	STD	STD	NO
Choice of Typomatic/Non-Typomatic Keyboard	STD	STD	NO
14" Screen	OPT	OPT	NO
N-Key Rollover	STD	STD	NO
CR New Line Mode	STD	STD	NO
Tilt and Swivel CRT	STD	STD	NO
User Programmable Non-Volatile Answerback, 32 Codes	STD	STD	NO
Screen Brightness Control from Keyboard	STD	STD	NO
XON/XOFF Flow Control, Split for Xmitter and Receiver	STD	STD	NO

Part No.	Description	List Price	Our Price	2 or More
BAVSL330GN	Green Screen 12"	$1200.00	$1050.00	$ 995.00
BAVSL33014GN	Green Screen 14"	$1250.00	$1095.00	$1050.00

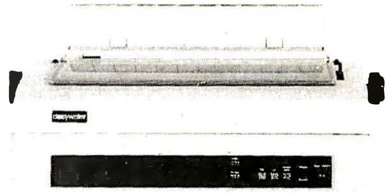
The VSL300 contains all of the same specifications as the 330 but with no multi-emulation capabilities. The VSL300 is ANSI X3.64 compatible

Part No.	Description	List Price	Our Price	2 or More
BAVSL300GN	Green Screen 12"	$1200.00	$1050.00	$ 995.00
BAVSL30014GN	Green Screen 14"	$1250.00	$1095.00	$1050.00

LOW COST DAISYWRITER 2000

WITH 40CPS EFFECTIVE SPEED AND 48K BUFFER

ONLY $1495.00!!



The SLMDW2000 may just be the best dollar value in a letter quality printer on the market today. Features include:

- Effective printing speed raised from 16cps to 40cps by the intelligent interface
- 48K buffer memory
- Daisyplot Graphics
- Printwheel cassettes available in 12 styles and 15 languages
- Standard IBM ribbon cartridges
- MTBF of 4000 hours at 25% duty cycle

This printer is DIP switch selectable for its personality protocols. This eliminates the need to replace a printer when the computer system is expanded, modified or adding additional printers that must be compatible with existing hardware and software. Included among the protocols that can be emulated are:

- NEC 5510 • DIABLO 630 • QUME Sprint 9
- IBM Personal Computer • ATARI (Centronics 737)

INTERFACES:

• RS232C and Current Loop • Centronics type parallel interface • IEEE/488 All are DIP switch selectable

SPECIAL FEATURES:

• Z80 CPU • 12K ROM • Standard 48K Buffer • 16 Softwareor hardware selectable baud rates 50 - 19.2K baud • Micro-coded alarm differentiates error conditions with pulse combinations • Intelligent bi-directional printing with logic seeking • Complete word processing features, standard • Complete self test • Autoreprint up to 255 times • Auto clear error - printer automatically resumes printing upon correction of ribbon, paper or cover open conditions • Proportional spacing • Supports Automatic justification • Complete Vector plotting routines • Sheet feeder mode - allows easy interface to most mechanical sheet feeders • Quite - 60db • Front panel forms control • Universal power supply 115/220V 50/60Hz

Part No.	Description	List Price	Our Price
BASLMDW2000	Printer with 48K buffer	$1595.00	$1495.00
BASLMDWVFT	Vertical Form Tractor		$ 125.00

Pre-configured cables are available. Please call for price and part number.

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Circle 328 on inquiry card.

SIEMENS FDD100-8 TRUCKLOAD PURCHASE!

WE'VE CAPTURED THE 8" FLOPPY DRIVE MARKET WITH A HUGE FACTORY DIRECT PURCHASE!!



FDD100-8
8" FLOPPY
WOW!!

SINGLE-SIDED
DOUBLE DENSITY
90 DAY WARRAN Y
SHUGART 801R COMPATIBLE

DUAL 8" SUBSYSTEM

BACCS2422A	Controller w/CP/M 2.2	1	$425.00
BASIEFDD1008	8" Drive	2	$498.00
IN A DUAL HORIZONTAL CABINET WITH POWER SUPPLY			$295.00
AND DATA CABLE		1	$ 35.00
SAVE $258.00			$1253.00

BAPDBSIESUB1

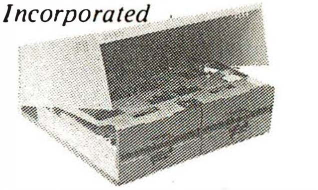
$995.00
(Include $30.00 for shipping)

Same as above, with CCS2810 Z80 4MHz CPU and CCS 2065 64K Dynamic RAM:
$1390.00
BAPDBSIESUB2

$265.00 1
$249.00 2-9
$215.00 10+
DASIEFDD1008
OEM INQUIRIES INVITED
(Include $7.00 per drive for shipping)

DON'T MISS OUT!

International Instrumentation Incorporated



- Positive Pressure Filter Cooling
- Power Supply 4A@ +5V,3A@ +24 V 1A@ -5V
- Each output is individually fused
- Hinged top for easy access
- Heavy non-flex .090 aluminum base
- Modular power connectors

BUY DRIVES AND CABINET TOGETHER AND $AVE!!

DUAL 8" SIEMENS FD01008,
DUAL 8" CABINET POWER SUPPLY
AND INTERNAL POWER CABLES
IF BOUGHT SEPARATELY: $910.00

PRICED AT: **$695.00**
BAPDBIIJSIE

ENVIRONMENT MONITOR PANEL

Temperature and voltage monitor with visual and audible alarm for overtemp condition. Direct Digital Readout of internal temperature in C on standard DVM

BAIIIFOE002	CABINET ONLY (Sh. Wt. 32 lbs.)	$295.00
BAPDBIIISIEEM	2-Drives, Cabinet & disk environment monitor	$775.00
BAIIIFDE002EM	Cabinet only with disk environment monitor	$375.00

VISUAL 50



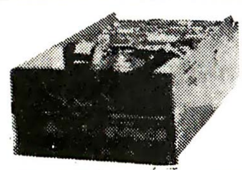
- Low profile detached keyboard features sculptured keys with matte finish
- Screen tilts and swivels
- 80 x 24 display with 25th status line
- 7 x 9 dot matrix with full decenders
- RS-232 Serial interface w/auxillary RS-232 port
- 128 Character ASCII set and 31 character line drawing set

INTRODUCTORY OFFER!!

BAVSL50BW	Non-glare Black& White	List: $695.00	Our Price: $650.00
BAVSL50GN	P31 green display	List: $750.00	Our Price: $685.00

(Shipping Weight 37 lbs.)

MITSUBISHI ELECTRIC



Better Than QUME! Better Than SHUGART!

8" Double-sided, double-density, interchangeable with QUME & Shugart

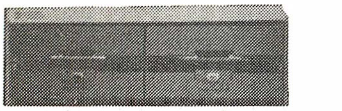
BAMITM289463	ShipingWeight 16 lbs.	$450.00
BAMITM289463M	Manual	$ 10.00

2 or More: $435.00 each

TWO MITSUDISHI 8" DRIVES DOUBLE SIDED DOUBLE DENSITY AND CABINET TOGETHER!!!

$1150.00
BAPDBMITFDE
DRIVES AND CABINET SHIPPED SEPARATELY

INTERNATIONAL INSTRUMENTATION, INC.



DUAL 8" FLOPPY DRIVE CABINET

FEATURES:
- Positive pressure forced air cooling for reliable disk drive operation
- AC input via 3 wire 7 foot international cord/socket set
- AC input EMI filtered to six amps to help prevent disk crashes due to power spikes and line noise
- 14 gauge main chassis
- Integral power supply with 5V@4A/-5V@1A/24V@6A
- Double-sided custom PC power board and supply
- Each DC supply and AC separately fused

8AIIIFOE002	*Shiping Weight 38 lbs*	$295.00

Tandon



8-INCH THIN LINE

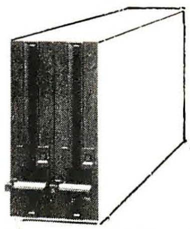
Exactly one-half the height of any other model
Proprietary, high-resolution, read-write heads patented by Tandon
D.C. only operation - no A.C. required
Industry standard interface
Three milisecond track-to-track access time (9 lbs.)

BATNOTM8481	Single Sided: $380.00	2 or more: $370.00 ea.
BATNOTM6482	Double Sided: $495.00	2 or more: $485.00 ea.

TANDON 5¼" DRIVES

BATNOTM1001	Single Sided, 250KB (5 lbs)	$220.00 ea.
	2 or More: $200.00 each	
BATNOTM1002	Double Sided, 500KB	$295.00 ea.
	2 or More: $270.00 each	
BATNOTM1003	Single Sided, 500KB	$295.00 ea.
	2 or More: $270.00 each	
BATNOTM1004	Double Sided, 1000KB	$395.00 ea.
	2 or More: $375.00 each	

DUAL THIN LINE CABINET by JMR



- Fan cooled
- 24V @ 4A/5A Surge
- 5V @ 2A
- Scratch Resistant Baked Enamel Finish

BAJMRTLC Cabinet & Power Supply List: $200.00 **Our Price: $180.00**
(Shipping Weight 12 lbs.)

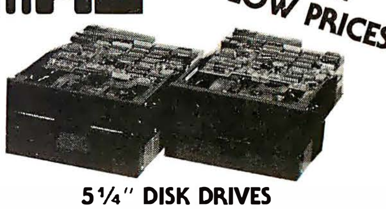
DUY THE CADINET AND DRIVES TOGETHER:

BAPOBJMRTN01	w/two TNDTM8481s	*(30 lbs.)*	$ 920.00
BAPOBJMRTN02	w/two TNDTM8482s	*(30 lbs.)*	$1150.00

Includes Power Cables

MPI

NEW LOW PRICES!

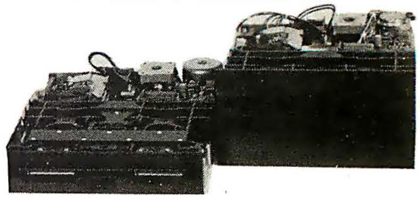


5¼" DISK DRIVES

BAMPI51*	Single-Sided Double-Density	48 TPI	$200.00
BAMPI52*	Double-Sided Double-Density	48 TPI	$270.00
BAMPI91*	Single-Sided Double Density	96 TPI	$275.00
BAMPI92*	Double-Sided Double-Density	96 TPI	$400.00

**Replace "*" when order, with "m" for MPI style bezel, or "S" for Shugart style bezel. (Shipping Weight: 5 lbs.)*

2" HIGH 8" DISK DRIVES



The first 2" high 8" disk drive allows for mounting under the keyboard on CRT, etc.
NO AC Required +5V +24VDC only
FAST 3 msec track to track!

BAMPI41M	½ High 1 side double-density	$380.00
BAMPI42M	½ High 2 side double-density	$460.00
BAMPI41S	Full height 1 side single drive, dble.-density	$380.00
BAMPI42S	Full height 2 sides single drive, dble.-density	$460.00
BAMPI41 0	Full height 1 side dual drive, dble.-density	$760.00
BAMPI420	Full height 2 side dual drive, dble.-density	$920.00

(Shipping Weight: 11 lbs. per drive.)

Circle 329 on inquiry card.

5" DISKETTES



SOFT SECTOR
40 TRACK SINGLE SIDED
DOUBLE DENSITY WITH
HUB REINFORCING RINGS

Package of 10: **$19.00**

BONUS!

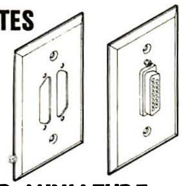


FREE!! KASSETTE 10 LIBRARY CASE WITH PACKAGE OF 10 DISKETTES
A $4.25 VALUE!! BAPRI5S00 (Shipping Weight: 2 lbs.)

BAPRI580 *package of 80, less Library Case* **$120.00**

EIA/RS232 WALL PLATES

(Does not include connectors)



BA111WP0B251 Single punched
4/$10.00
BA111WP0B252 Dual Punched
4/$12.00

RS-232 "D" SUB-MINIATURE CONNECTORS

		1-9	10-24	25-99
BACNDDB25P	25 Pin Male	$3.00	$2.75	$2.25
BACNDDB25S	25 Pin Female	$4.00	$3.75	$3.00
BACN00B51212	2 Pc. Grey Hood	$1.60	$1.45	$1.30
BACN0P25H	2 Pc. Grey Hood	$1.50	$1.25	$1.10
BACN00B51226	2 Pc. Black Hood	$1.90	$1.65	$1.45

TEXAS INSTRUMENTS
16 PIN GOLD AND TIN DIP SOLDERTAIL SOCKETS



QTY	TIN BATIS16LP	GOLD BAT1616LP
50	$ 8.00	$ 10.00
1000	$ 60.00	$ 80.00
4500	$225.00	$315.00

U.S. ROBOTICS

AUTO DIAL 212A MODEM $495.00

The **AUTO DIAL 212A** Modem is a direct connect 0-300 or 1200 baud modem capable of dialing and calling for you. **The AUTO DIAL 212A is compatible in function to the DC Hayes SMARTMODEM™.**

Part No.	Description	List	SALE Price
BAUSRADIAL212A	0-300, 1200 baud dialing modem	$599.00	**$495.00**



ACOUSTIC MODEM

The **PHONE LINK** Modem is a 300 baud RS232 compatible acoustic modem capable of operating as either an answer or originate modem. It is BELL 103/113 compatible and will accept most standard phone handsets.

BAUSRPLNK	0-300 Baud acoustic modem	$149.00	**$129.00**

MICRO LINK DIRECT CONNECT MODEMS

The **MICRO LINK** Modems are available in either 0-300 or 1200 baud transmission rates and both are RS232 compatible. Operation can be answer or originate.

BAUSRMLNK300	0-300 baud direct connect	$179.00	**$159.00**
BAUSRMLNK1200	1200 baud direct connect	$449.00	**$399.00**

AUTO LINK DIRECT CONNECT AUTO ANSWER MODEMS

The **AUTO LINK** Modems are auto answer modems capable of operating at 0-300 baud or 1200 baud transmission rates. The **AUTO LINK** Modems can be operated in either answer or originate modes.

BAUSRALNK300	0-300 baud auto/direct connect	$219.00	**$195.00**
BAUSRALNK1200	1200 baud auto/direct connect	$499.00	**$449.00**
BAUSRALNK212A	0-300, 1200 baud auto/direct	$549.00	**$475.00**

Specs	USRADIAL212A	USRALNK212A	USRALNK1200	USRMLNK1200	USRALNK300	USRMLNK300	USRPLNK
1200 Baud	X	X	X	X			
0-300 Baud	X	X			X	X	X
Auto Dial (Hayes Smartmodem compatible)	X						
Auto Answer	X	X	X		X		
Auto Mode Select	X				X	X	
DTR Override	X	X	X	X	X	X	
RS232 pins 2&3 reversible	X	X	X	X	X	X	
LED Indicators:	X	X	X	X	X	X	X
Carrier Detect	X	X	X	X	X	X	X
Analog Loopback/ Self Test	X	X	X	X	X	X	X
Send Data	X	X	X	X	X	X	X
Receive Data	X	X	X	X	X	X	X
Terminal Ready	X	X	X		X		
Off Hook	X	X	X		X		
Answer Mode	X	X	X		X		
Ring Indicate			X		X		
High Speed	X	X					

COMPLETE CompuPro™ SYSTEMS
FREE SUPERCALC-86! FREE dBASEII!!
AND A VISUAL 50 TERMINAL FOR ONLY $1.00!!

SYSTEM 816/A
ENTRY LEVEL SINGLE-USER SYSTEM



System **816/A** is an excellent choice for an entry level, single user system that's designed with future expansion in mind. **816/A** includes Interfacder 4 (three serial I/O ports, parallel port, and Centronics/Epson-style port), two RAM 17s for 128K of fast, static memory, and System Support 1 (clock calendar, RAM/ROM/match processor options, RS-232C serial port, interrupt controllers, interval timers, and more), and Ashton-Tate's dBase Junior™, an upgradeable subset of their popular dBase II data base management software. This combination of components means superb computing today with an option for future expansion — all the way up to a multi-user system. System **816/A** is priced at $5495.00, a savings of over $1000.00 compared to all components purchased separately.

BAGBTSYS816ADA	Single User System Desk Top, A&T	**$5495.00**
BAGBTSYS816ADC	Single User System Desk Top, 200 hr. Burn-in	**$6095.00**
BAVSL50BW	Visual 50 Black & White with Purchase of above system:	**$1.00**

FOURTH DIMENSION SYSTEMS
APPLE DISK DRIVES



Give your APPLE II® a Fourth Dimension—the totally compatible 5¼" drive that takes your system farther, faster. With read/write electronics so advanced that reading errors are virtually eliminated. With a track zero microswitch that keeps boot and track access smooth and quiet.

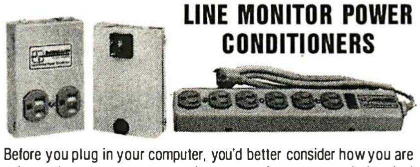
EXTENDED WARRANTY

Fourth Dimension offers a 12 month parts and labor warranty at no cost to you! (Gee, this really looks *GOOD!*)

BAFDS40A	List Price: $349.00	**SALE: $289.00**
BAFDS40AC*	Apple II® Disk Drive Controller	**$115.00**

*Sold only with the purchase of Fourth Dimension Drive

DATAGARD™ SGL WABER
LINE MONITOR POWER CONDITIONERS



Before you plug in your computer, you'd better consider how you are going to insure or protect your investment from unwanted electrical pollution.

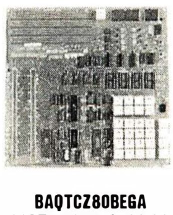
DG115 SERIES
SINGLE STAGE SPIKE PROTECTION

Part No.	Description	Wt.	List	SALE
BAWBROG115P	Wall unit plug in	2 lbs.	$49.95	$34.95
BAWBROG115S	6 outlet strip w/SW&LT	3 lbs.	$61.95	$42.00

DG315 SERIES
3 STAGE SPIKE FILTER AND FOUR STAGE NOISE FILTER

Part No.	Description	Wt.	List	SALE
BAWBROG315P	Wall unit plug in	2 lbs.	$153.95	$ 99.95
BAWBROG315S	6 outlet strip w/SW&LT	3 lbs.	$193.95	$119.95
BAWBROG315R	6 outlet track w/SW&LT	8 lbs.	$193.00	$119.95

QT COMPUTER SYSTEMS INC.



Z-80 BEGINNER KIT
Z80 CPU - 2 S-100 EXPANSION SLOTS

- Z80 CPU
- 2 S-100 slots for expansion
- Wire wrap area for cutom circuitry
- On board keyboard and display
- Cassette interface for mass storage
- 2K RAM included
- 4K ROM (not included)
- **RS232 port 300-19.2K baud**
- **Comes with ZBUG Monitor on ROM with S10 driver routines**
- TINY BASIC available

BAQTCZ80BEGA
LIST PRICE: $400.00
SALE PRICE: $340.00
(Shipping weight 4 lbs)

TINY BASIC ROM:
BAQTCTBASIC $25.00

COEX 80 F/T LOW COST DOT MATRIX PRINTER



• 80 cps • 10, 12 or 16.5 cpi • 3 selectable line spacing • Vertical format control • Centronics parallel interface • Use a standard Underwood spooled ribbon • Friction or tractor feed.

BACOX80FT List: $399.00 *(Shipping Wt 21 lbs.)* OUR PRICE **$349.00**

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Terms. U.S VISA, MC, BAC, Check, Money Order, U.S. Funds Only. CA residents add 6½% Sales Tax. MINIMUM PREPAID ORDER $15.00. Include MINIMUM SHIPPING & HANDLING of $3.00 for the first 3 lbs. plus 40¢ for each additional pound. Orders over 50 lbs. sent freight collect. Just in case, please include your phone number. Prices subject to change without notice. We will do our best to maintain prices through January, 1983. Credit Card orders will be charged appropriate freight. If you haven't received your Winter '83 Engineering Selection Guide, send $1.00 for your copy today! Sale prices for prepaid orders only.

Disk Drive for Apple II

$269.95

Apple II Accessories

APPLE DISK DRIVE - Apple Compatible

Totally Apple compatible, 143,360 bytes per drive on DOS 3.3, track 0 microswitch, high speed lead screw positioner, full one year factory warranty, half-track capability - reads all Apple software, plugs right in to Apple controller as second drive, DOS 3.3, 3.2.1, Pascal, & CP/M compatible.

MSM-123200 *Add-on Apple Drive* **$279.95**
MSM-123100 *Controller w/DOS 3.3* **$99.95**

16K RAM CARD - for Apple II

Expand your Apple II to 64K, use as language card, full 1 year warranty. Why spend $175.00 ?

MEX-16700A *Save over $115.00* **$59.95**

Z-CARD for Apple II - A.L.S.

Two computers in one, Z-80 & 6502, more than doubles the power and potential of your Apple, includes Z-80 CPU card CP/M 2.2 and complete manual set, Pascal compatible, utilities are menu-driven, one year warranty.

CPX-62800A *A & T with CP/M 2.2* **$169.95**

SMARTERM II - A.L.S.

80 column x 24 line video card for Apple II, addressable 25th status line, normal/inverse or high/low video, 128 ASCII characters, upper and lower case, 7 x 9 dot matrix with true descenders, standard data media terminal control codes, CP/M Pascal & Fortran compatible, 50/60 Hz, 40/80 column selection from keyboard

IOV-2500A *ALS Smarterm II* **$179.95**

SERIAL I/O CARD - A.L.S.

Full feature serial card for modems & printers, baud rates from 110 to 19,200, CTC/RTS & X-on/X-off protocols, auto line feed, RS-232C cable interface included.

IOI-1000A *A & T* **$79.95**

MODEM CARD for APPLE — SSM

Better than Hayes!! Better than Novation!! *Direct connect ModemCard plugs directly into Apple - no external components, auto-dial, auto-answer, Bell 103 compatible, full and half duplex, touch-tone or pulse dialing generated on board, Micromodem II software compatible, displays modem information on screen, audio monitoring of phone line, no serial port required, two year factory warranty,* ***FREE Source Subsrlption*** *with purchase of Transend software.*

IOM-3000A *ModemCard* **$289.95**
SFA-55770010M *Transend 1 w/Source* **$79.95**
SFA-55770020M *Transend 2 w/Source* **$129.95**
SFA-55770030M *Transend 3 w/Source* **$239.95**

2 MEGABYTES for Apple II

Complete package includes: Two 8" double-density disk drives, Vista double-density 8" disk controller, cabinet, power supply, & cables, DOS 3.2/3.3, CP/M 2.2, & Pascal compatible.

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JADE *Computer Products*

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ADD ON DISK DRIVE for IBM PC- Tandon

Single sided or double sided, double density disk drives for IBM PC, these are exactly the same disk drives used by IBM at half the price

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Two asynchronous serial RS-232C I/O ports, real time clock-calender, includes software

IOI-8100A *Card with 1 port* **$159.95**
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The Tasc Master is an intelligent parallel printer and dual port asynchronous communication adapter with built in buffer, two RS-232C I/O ports, parallel printer I/O port, 16K or 64K buffer, on-board CPU increases system throughput

IOI-8120A *1 serial/parallel/16K* **$329.95**
IOI-8121A *1 serial/parallel/64K* **$399.95**
IOI-8122A *2 serial/parallel/16K* **$359.95**
IOI-8123A *2 serial/parallel/64K* **$429.95**

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All bus signals extended, signal names silk screened on top of board, gold-plated card edge, low noise

TSX-300A *IBM PC extender* **$45.00**

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Highly versatile wire-wrap or solder prototyping board for your IBM PC, large bread board area, power and ground planes to reduce noise, all holes are plated through, card is solder masked on both sides, all signals names are silk screened on both sides

TSX-310A **$59.95**

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A high quality, high density memory expansion board for your PC, cool-quiet-reliable operation, full parity checking, unique stacking sockets, expandable from 256K to 512K, MDRIVE high speed RAMdisk software only $25.00 with board purchase

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MEX-51200A *512K Assembled & tested* **$999.95**
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256K PC/RAM - Hammond Engineering

User expandable from 64K to 256K, same high quality as RAM STACK above, designed to meet all your medium memory expansion requirements

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Three boards in one, 256K of RAM, RS-232C asynchronous serial interface, and a SASI (Shugart Associates Standard Interface) hard disk interface

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15 MHz bandwith 700 lines/inch, P31 green phosphor, switchable 40 or 80 columns, small, light-weight & portable

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VDC-651212 *Color monitor* **$389.95**
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SUPERQUAD - Adv. Micro Digital

Single board, standard size S-100 computer system, 4 MHz Z-80A, single or double density disk controller for 5¼" or 8" drives, 64K RAM, extended addressing, up to 4K of EPROM, 2 serial & 2 parallel I/O ports, real time interrupt clock, CP/M compatible.

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Complete Z-80 microcomputer with RAM, ROM, I/O, keyboard, display, kludge area, manual, & workbook.

CPS-30100K *Kit with workbook* **$299.95**
CPS-30100A *A & T with workbook* **$469.95**

S-100 EPROM Boards

PB-1 - SSM Microcomputer

2708, 2716 EPROM board with on-board programmer.

MEM-99510K *Kit with manual* **$154.95**
MEM-99510A *A & T with manual* **$219.95**

PROM-100 - SD Systems

2708, 2716, 2732 EPROM programmer with software.

MEM-99520K *Kit with software* **$189.95**
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S-100 MotherBoards

ISO-BUS - Jade

Silent, simple, and on sale - a better motherboard

6 Slot (5¼" x 8⅝")

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MBS-121K *Kit* **$69.9**
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MBS-181B *Bare board* **$54.9**
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A true mother's helper.

TSX-100A *A & T* **$59.4**

Circle 214 on inquiry card.

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NEW CP/M 3.0 - Digital Research

CP/M 3.0 is Digital Research's latest version of the industry standard disk operating system. It features many performance improvements such as intelligent record buffering, improved directory handling, "HELP" facility, time/date stamping of files and many more improvements. AND A TREMENDOUS INCREASE IN SPEED !!!, it is fully CP/M 2.2 compatible and requires no changes to your existing application software. Available only to Versafloppy II owners with SBC-200 CPU's

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- ***Automatic disk log-in of removable media***
- ***Support for 1 to 16 banks of RAM***
- ***Supports up to 16 drives of 512 Megabytes each***
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- ***Designed with the business user in mind***

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New CP/M Plus Version 3.0 FREE !!! *

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FREE CP/M 3.0 Save $800.00

S-100 board set with 4 MHz Z-80A, 64K of RAM expandable to 256K, serial and parallel I/O ports, double-density disk controller for 5¼" and 8" disk drives, new and improved CP/M 3.0 manual set, system monitor, control and diagnostic software. Includes SD Systems SBC-200, 64K ExpandoRAM III, Versafloppy II, and FREE CP/M 3.0 - all boards are assembled & tested.

* **64K Board Set with FREE CP/M 3.0**	**$1195.00**
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FREE CP/M 2.2 Save $700.00

Limited Quantity

*S-100 board set featuring high speed DMA CPU and disk controller, includes 4 MHz DMA Z-80A CPU, 64K of high speed RAM, 2 serial and 1 parallel I/O ports, double-density DMA disk controller for 5¼" or 8" drives, **FREE CP/M 2.2** on 8" disk with full manual set, all necessary diagnostic and control software. Package consists of the new CCS 282C DMA CPU, new CCS DMA disk controller (not the old 2422), & CCS 2065 64K RAM, and **FREE CP/M 2.2** - all boards are assembled & tested with full factory warranty.*

SPECIAL PACKAGE PRICE *Save over $700.00* .. **$694.95**

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S-100 Memory Boards

256K RAMDISK - SD Systems

ExpandoRAM III expandable from 64K to 256K using 64K x 1 RAM chips, compatible with CP/M, MP/M, Oasis, Cromemco, & most other Z-80 based systems, functions as ultra-high speed disk drive when used with optional RAMDISK software.

MEM-65064A	*64K A & T*	**$474.95**
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MEM-65192A	*192K A & T*	**$674.95**
MEM-65256A	*256K A & T*	**$774.95**
SFC-55009000F	*RAMDISK sftwr CP/M 2.2*	**$44.95**
SFC-55009000F	*RAMDISK with EXRAM III*	**$24.95**

64K STATIC RAM - Jade

Uses new 2K x 8 static RAMs, fully supports IEEE696 24 bit extended addressing, 200ns RAMs, lower 32K or entire board phantomable, 2716 EPROMs may be subbed for RAMs, any 2K segment of upper 8K may be disabled, low power typically less than 500ma.

MEM-99152B	*Bare board*	**$49.95**
MEM-99152K	*Kit less RAM*	**$99.95**
MEM-32152K	*32K kit*	**$199.95**
MEM-56152K	*56K kit*	**$289.95**
MEM-64152K	*64K kit*	**$299.95**
Assembled & Tested		**add $50.00**

16K STATIC RAM - Mem Merchant

4MHz lo-power static RAM board, IEEE S-100, bank selectable, addressable in 4K blocks, disable-able in 1K segments extended addressing.

MEM-16171A	*16K A & T*	**$149.95**

S-100 Disk Controllers

DISK 1 - CompuPro

8" or 5¼" DMA disk controller, single or double density, single or double sided, 10 MHz.

IOD-1810A	*A & T*	**$449.95**
IOD-1810C	*CSC*	**$554.95**

VERSAFLOPPY II - SD Systems

Double density disk controller for any combination of 5¼" and 8" single or double sided, analog phase-locked loop data separator, vectored interrupts, CP/M 2.2 & Oasis compatible, control/diagnostic software PROM included.

IOD-1160A	*A & T with PROM*	**$359.95**
SFC-55009047F	*CP/M 3.0 with VF II*	**$99.95**

2242 DISK CONTROLLER - C.C.S.

5¼" or 8" double density disk controller with on-board boot loader ROM, free CP/M 2.2 & manual set.

IOD-1300A	*A & T with CP/M 2.2*	**$399.95**

DOUBLE D - Jade

High reliablity double density disk controller with on-board Z-80A, auxiliary printer port, IEEE S-100, can function in multi-user interrupt driven bus.

IOD-1200B	*Bare board & hdwr man*	**$59.95**
IOD-1200K	*Kit w/hdwr & sftwr man*	**$299.95**
IOD-1200A	*A & T w/hdwr & sftwr man*	**$325.95**
SFC-59002001F	*CP/M 2.2 with Double D*	**$99.95**

S-100 I/O Boards

I/O-4 - SSM Microcomputer

2 serial I/O ports plus 2 parallel I/O ports.

IOI-1010B	*Bare board w/manual*	**$35.00**
IOI-1010K	*Kit with manual*	**$179.95**
IOI-1010A	*A & T with manual*	**$249.95**

I/O-5 - SSM Microcomputer

Two serial & 3 parallel I/O ports, 110-19.2K Baud

IOI-1015A	*A & T*	**$289.95**

INTERFACER 4 - CompuPro

3 serial, 1 parallel, 1 Centronics parallel.

IOI-1840A	*A & T*	**$314.95**
IOI-1840C	*CSC*	**$414.95**

THE BUS PROBE - Jade

Inexpensive S-100 Diagnostic Analyzer

So your computer is down. And you don't have an oscilloscope. And you don't have a front panel... You're not alone - most computers have their occasional bad days. But without diagnostic equipment such as an oscilloscope (expensive!) or a front panel (expensive!), it can be very difficult to pinpoint the problem. Even if you have an extender board with a superfast logic probe, you can't see more than one signal at a time. You're stuck, right?

*Not anymore; Jade is proud to offer our cost-effective solution to the problems mentioned above: **THE BUS PROBE.***

Whether you're a hobbyist with a cantankerous kluge or a field technician with an anxious computer owner breathing down your neck, you'll find THE BUS PROBE speeds your repair time remarkably. Just plug in THE BUS PROBE and you'll be able to see all the IEEE S-100 signals in action. THE BUS PROBE allows you to see inputs, outputs, memory reads and writes, instruction fetches, DMA channels, vectored interrupts, 8 or 16 bit wide data transfers, plus the three bus supply voltages.

TSX-200B	*Bare board*	**$59.95**
TSX-200K	*Kit*	**$129.95**
TSX-200A	*A&T*	**$159.95**

S-100 CPU Boards

SBC-200 - SD Systems

4 MHz Z-80A CPU with serial & parallel I/O, 1K RAM, 8K ROM space, monitor PROM included.

CPC-30200A	*A & T*	**$329.95**

THE BIG Z - Jade

2 or 4 MHz switchable Z-80 CPU board with serial I/O, accomodates 2708, 2716, or 2732 EPROM, baud rates from 75 to 9600.

CPU-30201B	*Bare board w/manual*	**$35.00**
CPU-30201K	*Kit with manual*	**$149.95**
CPU-30210A	*A & T with manual*	**$199.95**

2810 Z-80 CPU - C.C.S.

2 or 4 MHZ Z-80 CPU with serial I/O port & on-board monitor PROM. front panel compatible.

CPU-30400A	*A & T with PROM*	**$289.95**

CPU-Z - CompuPro

2/4 MHz Z80A CPU, 24 bit addressing.

CPU-30500A	*2/4 MHz A & T*	**$279.95**
CPU-30500C	*3/6 MHz CSC*	**$374.95**

8085/8088 - CompuPro

Both 8 & 16 bit CPUs, standard 8 bit S-100 bus, up to 8 MHz, accesses 16 Megabytes of memory.

CPU-20510A	*6 MHz A & T*	**$398.95**
CPU-20510C	*6/8 MHz CSC*	**$497.95**

S-100 Video Boards

MICROANGELO - Scion

Ultra-high-resolution 512 x 480, 256 color or black & white S-100 video board

IOV-1500A	*A & T*	**$799.95**

JADE ***Computer Products***

Circle 214 on inquiry card.

8" Disk Drive Double-Density $249.95

8" Disk Drives

Siemens FDD 100-8 *single-sided double-density*			
MSF-201120		$274.95 ea	2 for **$249.95 ea**
Shugart SA810 *half-size single-sided double-density*			
MSF-108100		$424.95 ea	2 for **$394.95 ea**
Shugart SA860 *half-size double-sided double-density*			
MSF-108600		$574.95 ea	2 for **$549.95 ea**
Shugart SA801R *single-sided double-density*			
MSF-10801R		$394.95 ea	2 for **$389.95 ea**
Shugart SA851R *double-sided double-density*			
MSF-10851R		$554.95 ea	2 for **$529.95 ea**
Tandon TM848-1 *single-sided double-den thin-line*			
MSF-558481		$379.95 ea	2 for **$369.95 ea**
Tandon TM848-2 *double-sided double-den thin-line*			
MSF-558482		$494.95 ea	2 for **$484.95 ea**
Qume DT-8 *double-sided double-density*			
MSF-750080		$524.95 ea	2 for **$498.95 ea**

5¼" Disk Drives

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MSM-551001		$219.95 ea	2 for **$199.95 ea**
Shugart SA400L *single-sided double-density 40 track*			
MSM-104000		$234.95 ea	2 for **$224.95 ea**
Shugart SA455 *half-size double-sided 48 TPI*			
MSM-104550		$349.95 ea	2 for **$329.95 ea**
Shugart SA465 *half-size doule-sided 96 TPI*			
MSM-104650		$399.95 ea	2 for **$379.95 ea**
Tandon TM100-2 *double-sided double-density 48 TPI*			
MSM-551002		$294.95 ea	2 for **$269.95 ea**
Shugart SA450 *double-sided double-density 35 track*			
MSM-104500		$349.95 ea	2 for **$329.95 ea**
Tandon TM100-3 *single-sided double-density 96 TPI*			
MSM-551003		$294.95 ea	2 for **$269.95 ea**
Tandon TM100-4 *double-sided double-density 96 TPI*			
MSM-551004		$394.95 ea	2 for **$374.95 ea**
MPI B-51 *single-sided double-density 40 track*			
MSM-155100		$234.95 ea	2 for **$224.95 ea**
MPI B-52 *double-sided double-density 40 track*			
MSM-155200		$344.95 ea	2 for **$334.95 ea**

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END-000216	*Single cab w/power supply*	**$69.95**
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Dual Disk Sub-Systems

Disk Sub-Systems - Jade

Handsome metal cabinet with proportionally balanced air flow system, rugged dual drive power supply, power cable kit, power switch, line cord, fuse holder, cooling fan, never-mar rubber feet, all necessary hardware to mount 2-8" disk drives, power supply, and fan, does not include signal cable.

Dual 8" Sub-Assembly Cabinet

END-000420	*Bare cabinet*	**$49.95**
END-000421	*Cabinet kit*	**$199.95**
END-000431	*A & T*	**$249.95**

8" Sub-Systems - Single Sided, Double Density

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END-000424	*A & T w/2 FD100-8Ds*	**$695.00**
END-000433	*Kit w/2 SA-801Rs*	**$999.95**
END-000434	*A & T w/2 SA-801Rs*	**$1195.00**

8" Sub-Systems - Double Sided, Double Density

END-000426	*Kit w/2 DT-8s*	**$1224.95**
END-000427	*A & T w/2 DT-8s*	**$1424.95**
END-000436	*Kit w/2 SA-851Rs*	**$1274.95**
END-000437	*A & T w/2 SA-851Rs*	**$1474.95**

8" Slimline Sub-Systems

Dual Slimline Sub-Systems - Jade

Handsome vertical cabinet with scratch resistant baked enamel finish, proportionally balanced air flowsystem, quiet cooling fan, rugged dual drive power supply, power cables, power switch, line cord, fuse holder, cooling fan, all necessary hardware to mount 2-8" slimline disk drives, does not include signal cable.

Dual 8" Slimline Cabinet

END-000820	*Bare cabinet*	**$59.95**
END-000822	*A & T w/o drives*	**$179.95**

Dual 8" Slimline Sub-Systems

END-000823	*Kit w/2 TM848-1*	**$919.95**
END-000824	*A & T w/2 TM848-1*	**$949.95**
END-000833	*Kit w/2 TM848-2*	**$1149.95**
END-000834	*A & T w/2 TM848-2*	**$1179.95**

Modems

SIGNALMAN - Anchor

Direct-connect automatic answer/originate selection, 300 Baud full duplex, Bell 103, includes RS-232 cable, portable - perfect for Osborne or KayPro II

IOM-5600A	*Signalman*	**$89.95**

SMARTMODEM - Hayes

Sophisticated direct-connect auto-answer/auto-dial modem, touch-tone or pulse dialing, RS-232C interface, programmable

IOM-5400A	*Smartmodem*	**$224.95**
IOK-1500A	*Hayes Chronograph*	**$218.95**
IOM-2010A	*Micromodem II w/Term prgm*	**$329.95**
IOM-2012A	*Terminal program for MMII*	**$89.95**
IOM-1100A	*Micromodem 100*	**$368.95**

1200 BAUD SMARTMODEM - Hayes

1200 and 300 baud, all the features of the standard Smartmodem plus 1200 baud, 212 compatible, full or half duplex.

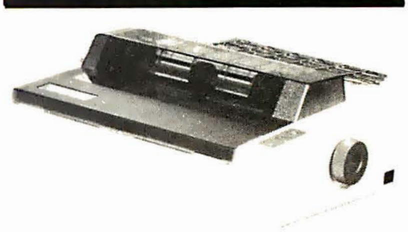
IOM-5500A	*Smartmodem 1200*	**$599.95**

1200 BAUD SMART CAT - Novaton

103/212 Smart Cat & 103 Smart Cat, 1200 & 300baud, built-in dialer, auto re-dial if busy, auto answer/disconnect, direct connect, LED readout displays mode, analog/digital loop-back self tests, usable with multi-line phones.

IOM-5241A	*300 baud 103 Smart Cat*	**$229.95**
IOM-5251A	*1200 baud 212/103 Smart Cat*	**$549.95**
IOM-5261A	*300 baud 103 J-Cat*	**$129.95**

Printers on Sale



PRINTER PRICES SLASHED !!!

*High speed dot matrix printers with all the features of the higher-priced best-selling machines for a lot less money!!! **100 CPS**, 9 x 9 dot matrix with true lower case descenders, high-resolution bit image and block graphics, superscript & subscript, underlining, backspacing, double strike and emphasized print modes, proportional space font, friction feed, tractor feed, and roll paper, 5, 6, 8½, 10, 12, & 17 pitch, programable line spacing, **FREE 2.3K buffer**, Epson pin and plug compatible, user replaceable print head, extended 6 month factory warranty.*

PRM-66010	*10" wide carriage*	**$439.95**
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PRA-66100	*Apple card & cable*	**$45.00**
PRA-66200	*Serial interface card*	**$69.95**

HIGH-SPEED, HIGH QUALITY - Okidata

Microline 82A *80/132 column, **120 CPS**, 9 x 9 dot matrix, friction feed, pin feed, adjustable tractor feed (optional), handles 4 part forms up to 9.5" wide, rear & bottom feed, paper tear bar, 100% duty cycle/200,000,000 character print head, bi-directional/logic seeking, **both serial & parallel interfaces included**, front panel switch & program control of 10 different form lengths, uses inexpensive spool type ribbons, double width & condensed characters, true lower case descenders & graphics*

PRM-43082	*with FREE tractor*	**CALL**

Microline 83A *132/232 column, 120 CPS, forms up to 15" wide, removable tractor, plus all the features of the 82A.*

PRM-43083	*with FREE tractor*	**CALL**

Microline 84 *132/232 column, Hi-speed 200 CPS, full dot graphics built in, plus all the features of the 83A.*

PRM-43084	*Centronics parallel*	**CALL**
PRM-43085	*Serial with 2K buffer*	**CALL**

PRA-27081	*Apple card*	**$39.95**
PRA-27082	*Apple cable*	**$19.95**
PRA-27087	*TRS-80 cable*	**$24.95**
PRA-43081	*2K hi speed serial card*	**$149.95**
PRA-43082	*Hi-res graphics ROMs 82A*	**$49.95**
PRA-43083	*Hi-graphics ROMs 83A*	**$49.95**
PRA-43088	*Tractor option for 82A*	**$49.95**
PRA-43080	*Extra ribbons pkg. of 2*	**$9.95**

8023 DOT MATRIX - NEC

100 CPS, proportional spacing, hi-resolution graphics, correspondence quality printing, bi-directional tractor & friction feed.

NEC-8023A	*8023 parallel*	**$499.95**
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Letter Quality Printers

LETTER QUALITY PRINTER - Jade

Uses standard daisy wheels and ribbon cartridges, 16 CPS bi-directional printing, semi-automatic paper loader (single sheet or fan fold), 10/12/15 pitch, up to 16" paper, built-in noise suppression cover.

PRD-11001	*Centronics parallel*	**$899.95**
PRD-11002	*RS-232C serial model*	**$969.95**
PRA-11000	*Tractor Option*	**$119.95**

STARWRITER F-10 - C. Itoh

New 40 CPS daisy wheel printer with full 15" carriage, uses standard Diablo print wheels and ribbons, both parallel and serial interfaces included.

PRD-22010	*Starwriter F-10*	**$1495.95**

TP-1 LETTER QUALITY - SCM

12 CPS daisy wheel printer from Smith Corona.

PRD-45101	*Centronics parallel*	**$648.95**
PRD-45102	*RS-232C serial*	**$648.95**

PRINTER PALS - F.M.J. Inc.

Desk top printer stand and continuous form paper holder.

PRA-99080	*for MX-80, MX-80FT, Oki 82A, NEC*	**$29.95**
PRA-99100	*for MX-100, Oki 83A & 84*	**$34.95**
PRA-99700	*for letter quality printers*	**$49.95**

Circle 215 on inquiry card.

Unclassified Ads

WANTED: Used DOS equipment: Apple, IBM, TRS, etc. Vermont land trust is overwhelmed by accumulation of data from herbariums, museum collections, and literature searches on the habitats of endangered species. Your tax-deductible donations of used micro equipment will be most welcome. We will pay shipping. Robert Klein, Nature Conservancy, 7 Main St., Montpelier, VT 05602, (802) 229-4425.

FOR SALE: Microtek MT-80P parallel printer for the Apple II. Brand-new print head. Printer, 4-foot cable, and Apple parallel card for $550 or best offer. Also, an Apple Integer card for $100. Both like new. Doug Geoffray, 2404 Wells St., Fort Wayne, IN 46808, (219) 483-7939.

FOR SALE: Apple Silentype printer (40 cps and dumps high-resolution screens) with interface card, instruction manual, and 4 rolls of paper: $250. Sanyo VM 4509 monitor (9-inch black-and-white screen) uses AC/DC: $120. Mountain Hardware Speechlab 20A (32-word vocabulary/speech-recognition card for the Apple). Includes disk of software and instruction manual: $115. Also, will sell TI-59 programmable calculator and PC100-C printer for $300 or will trade for peripherals for Apple. Haydn Huntley, POB 1111, Fairfield, IA 52556, (515) 472-8116.

WANTED: Expansion interface for TRS-80 Model I. Any condition, with or without memory. Also, disk drive. M. Braun, Rt. 5, Box 582, Burlington, IA 52601, (319) 754-5027.

FOR SALE: 1976 and 1977 issues of BYTE, Interface, Kilobaud Microcomputing, Microtek, Dr Dobbs, etc. $100 for set. Eric Schneck, 407 East 91 St., New York, NY 10028, (212) 722-5728.

WILL TRADE: Qualified individual will trade custom microcomputer software development for microcomputer hardware. William H. Roetzheim, 3891 American Ave., La Mesa, CA 92041, (714) 466-0400 or 466-0618.

FOR SALE: All Digital Group equipment in DG brown cabinets. Z80+ processor, motherboard (with all sockets), and dual-density Controller III by RW Sales. Processor has on-board CMOS clock/calendar and 2708/2716 EPROM boot pages with un-ROM control. Two SA-800 floppy disks, two 32K Bell Controls static memory, Centronics 737 printer, 9-inch monitor, and Keytronics Selectric-style keyboard. $2800 you ship. Pat Snyder, 2001 Brenner Ave. W., Roseville, MN 55113, (612) 636-5103.

FOR SALE: Heath GR104A black-and-white TV in good working condition, makes good monitor, 110-VAC or 12-VDC power; $65. Electronic Systems Type 103 modem in new, never-used condition; $25. 16K memory board for expanding 48K H/Z-89 computer to 64K in new condition, working fine; $65. Full documentation included for all items. Shipping charges paid. J. C. Williams, Rt. 2, Box 207E, Buchanan, VA 24066, (703) 254-1686.

FOR SALE: Ten 3M DC-300A magnetic-tape cartridges. New condition. R. Blair, Apt. #102, 5800 Hollister Rd., Houston, TX 77040, (713) 462-7306.

FOR SALE: 32K CBM/PET big keyboard computer, $800. 4040 dual disks, $800. 2022 printer, $450. C2N cassette, $70. MTU visible graphics board, $300. Also, Toolkit, WP3, terminal software (PTERM3), JINSAM 3.0, and more than 100 programs. Package worth more than $4500, will sell for $2400, or as individually priced. Jerry, (313) 763-4403 (days), 426-8690 (nights).

FOR SALE: TRS-80 Model I, with 16K and Level II BASIC. Keyboard unit, display, power supply, tape recorder, dust covers, some game and utility software, blank tapes, and all manuals. Excellent condition, $500 (I will pay shipping in U.S.). First certified check, cashier's check, or money order takes all. Offers considered. David Shinn, 28 Wagon Bridge Run, Moorestown, NJ 08057.

FOR SALE: Two DECwriters Model LA-30, schematics and maintenance manuals included. Very good condition, 100/150/300 bps, $425 each. Rick Michelhaugh, 211A Cairn Circle, Knoxville, TN 37923, (615) 693-4182.

FOR SALE: OSI Challenger C2-8P with 48K memory, OSI CD2 dual disk drive, Koyo TMC-9M 7-inch monitor, and Integral Data Systems DMTP-G matrix printer. Asking $2000. V. Baus, 151 East Merrill, Fond du Lac, WI 54935, (414) 922-0970 before 5 p.m.

FOR SALE: Handi-Keys custom-design keyboards for the TRS-80 Model II. Enter text for analysis of keys used by each finger and hand. Machine-lanugage driver changes keyboard to Dvorak. One-handed or user-defined. Analyze typing lessons. Disk and instructions for $36. Ronald Mc Cuiston, 5795 Adelyn Rd., Pensacola, FL 32504.

WANTED: The following SwTPC equipment: AC-30 cassette interface, CT-1024 terminal, CT-64 terminal, and other items. Harvey Lipowitz, 7827 Lorna Dr., Philadelphia, PA 19111, (215) 745-6283.

FOR SALE: Epson MX-100, brand new, full warranty. Lists at $995, will sacrifice for $500. Epson MX-80, brand new, full warranty. Lists at $645, must sell for $300. Texas Instruments TI 820RO matrix printer. Lists at $2500, must sell for $1500. Auto-Cat modem by Novation. Direct-connect, never used, perfect for any personal computer. Lists at $299.95, will sacrifice for $175. IBM Visicalc, never used. Lists at $270, will sacrifice for $125. IBM Easy Writer, never used. Lists at $195, must sell for $95. Jim Campbell, 309 Cordova Dr., Santa Barbara, CA 93109, (805) 966-2921, evenings PT.

FOR SWAP: Hollis Super 7 deep-wave soldering system (complete and operational) for automatic soldering of computer circuit boards. Consists of soldering station conveyer with speed control and solid-state drive. Fluxer and preheater. All in exchange for one microcomputer with multi-user and tasking capability, RAM memory included with a compatible DOS software-control system. Sid Dalinka, 300 Winston Dr., Cliffside Park, NJ 07010, (201) 224-2721.

FOR SALE: Motorola green-phosphor video monitor with an anitglare screen and composite video input. In very good condition without case. First $60 plus shipping takes it. If you reply within two weeks of this ad's first appearance, I'll throw in a Texas Instruments terminal board. J. Marketos, 1210 Wordens Pond Rd., Wakefield, RI 02879, (401) 789-4369.

FOR SALE: North Star computer with two double-density disk drives, 56K RAM, and loads of the finest professional software (business, educational, games, and utilities). With Hazeltine 1500 terminal and cable. All for $3650, including shipping, insurance, and disk libraries. Evan Katz, POB 202, Greenvale, NH 11548, (516) 626-0004.

FOR SALE: Netronics 1802 microcomputer with two anything boards for $45 each. One programming board for $65. Heath 10-4541 5 MHz portable oscilloscope for $185. Heath decade capacitance box for $40. Heath decade resistance box for $50. All equipment has manuals and is guaranteed to be in excellent working order. All plus postage. Aloha. Phillip N. Blake, 709 Pio Dr., Wailuku, HI 96793, (808) 244-3668.

FOR SALE: Computer tapes: 10½-inch reel, 3⅝-inch hub, ½-inch wide tape, 2400 feet, 9-track, used but in good condition; $3 each. Leland Barber, 301 Boyle Rd., Gill, MA 01376, (413) 863-9086.

FOR SALE: Original (1973) Magnavox Odyssey video game. Rare and complete. Best offer. Also, various computer magazines including: BYTE (Vol. 1, #1 to present), Kilobaud Microcomputing (Vol. 1, #1 to present), Creative Computing (Vol. 3, #1 to present), ROM (all nine issues), Interface Age (Vol. 1, #4 to Vol. 6, #1), and many more. Best offer for all or part. Send SASE for complete list. Dave Repsher, 1915 Verde St., Bakersfield, CA 93304, (805) 324-6180.

FOR SALE: NEC 8023-A printer, used only a few minutes, mint condition. Selling due to incompatibility with my computer. I'll pay shipping for the first cashier's check received for $550. Doug Clapp, 620 Stuart Ave., Crookston, MN 56716, (218) 281-1983.

FOR SALE: HP41-Chess. Knows all the rules. Very strong. Very fast. Price: 2000 Flux (40S). Bank Transfer: 332/014507/00 Banque Generale Luxembourg. Claude Roeltgen, Rue d'Ehlerange 44, L-3918 Mondercange Luxembourg, Europe.

FOR SALE: Silentype printer with interface for Apple II. $330 with eight rolls of paper. John A. Reyburn Jr., 761 Bolsa Chica, Goleta, CA 93117, (805) 964-8224.

WANTED: IBM 370 utility program to read and write disks in the IBM OS/6 format, via an IBM 3540 disk input/output unit that is a peripheral on the 370. Brian D. Harney, 1324 Saddleback Trail, Frankfort, KY 40601.

FOR SALE: Complete TRS-80 Model I with expansion interface and 48K RAM, three disk drives, and a tractor-feed printer. High-resolution graphics package. Like new. All for $1950. FOB. J. H. Glenn, 114 South 7th St., Hilbert, WI 54129.

FOR SALE: Televideo 912C in like-new condition: $650. Rich Pagnusat, 3725 North 25th Ave., Schiller Park, IL 60176, (312) 671-6180 between 8 a.m. and 4 p.m. CT.

FOR SALE: Intel 8080 System Design Kit (SDK-80) with monitor ROM. Board is fully socketed for ICs. Never used. Documentation includes: 8080 Users Manual, Assembly Language Manual, Programmers Reference Card, PL/M Programmers Manual, and SDK-80 Users Guide: $125. Tom Vilov, 603 Homewood Dr., Pocomoke, MD 21851, (301) 957-1407.

FOR SALE: TRS-80 Model II, 64K, two 8-inch double-sided floppy-disk drives, TRS-80 Line Printer III with stand, workstation, BASIC, Cobol, Inventory System, and Mailing List System: $4850 for full system. Greg Hoffman, POB 208, Brookfield, CT 06804, (203) 775-1291 days, 354-8657 evenings and weekends.

FOR SALE: Texas Instruments 99/4A computer with 32K memory expansion, disk drive and controller, and interface; $1100. Warren English, 130 Buckwood Dr., Richmond, KY 40475, (606) 624-1676.

WANTED: Video terminal, printer, and modem. Bernd Riechelmann, POB 17344, San Diego, CA 92117, (714) 292-4196.

FOR SALE: 8K OSI Super Board II with metal case and power supply. Includes several manuals and two dozen games, $230. Tim Snow, 16 Grant St., Potsdam, NY 13676, (315) 265-3739.

UNCLASSIFIED POLICY: Readers who have computer equipment to buy, sell, or trade or who are requesting or giving advice may send a notice to BYTE for inclusion in the Unclassified Ads section. To be considered for publication, an advertisement must be non-commercial (individuals or bona fide computer clubs only), typed double-spaced on plain white paper, contain 75 words or fewer, and include complete name and address. This service is free of charge; notices are printed once only as space permits. Your confirmation of placement is appearance in an issue of BYTE as we engage in no correspondence. Please allow at least three months for your ad to appear. Send your notices to Unclassified Ads, BYTE/McGraw-Hill, POB 372, Hancock, NH 03449.

Unclassified Ads

FOR SALE OR TRADE: Have: BYTE Volume 5, Numbers 3 and 6-12; Volume 6, Numbers 1-7 and 9; Volume 4, Number 8; and Volume 3, Number 4. Asking $1 plus postage. Need: BYTE Volume 1, Numbers 1-12; Volume 2, Numbers 1-5 and 7-10; Volume 3, Numbers 1, 2, 3, 9 and 12. Volume 4, Numbers 3 and 9-12. Walter Vose Jeffries, RFD 1 Box 218, Readfield, ME 04355 (207) 685-4380.

WANTED: I wish to correspond with people who are interested in computers (homebrew or types being sold) lasers, and other areas of electronics. Also would like to exchange ideas and maybe even do some joint projects. For example, how two or more people could build a compatible homebrew system. Carlos Brimer, Rt. 1 Box 153, Doyle, TN 38559.

FOR SALE: OSI C8P computer with dual 8-inch floppy disks and 48K RAM. Includes Epson MX-80 printer, black-and-white video monitor, and OS-65D and OS-65U operating systems. Complete documentation as well as four boxes of disks containing numerous business, home, and game programs. Make an offer. Carl Robbins, 263 Glenwood Rd., Wheeling, WV 26003, (304) 233-2624.

FOR SALE: Heath H-9 video-display terminal modified for 24 lines and assembled, working H-8 with 16K memory, H-8-5 serial RS-232C and cassette-interface board. Included are Extended BASIC, Regular BASIC, TED-8, HASL-8, all operations manuals, Heath BASIC programming course material, and several games on cassette. $500 or make an offer. Lee Widener, POB 400, High Rolls, NM 88325, (505) 682-2633.

WANTED: Schematics for the Viatron 21 system, especially the driver board for the Robot Printer unit. I will, of course, pay for expenses and copying. Allan Rothman, 19 Roberta Lane, Syosset, NY 11791.

FOR SALE OR TRADE: Forms tractor for Diablo 630/1640 in perfect condition. $100 or same value in supplies (paper, ribbons, etc.) J. Fitzpatrick, 2 Southboro Lane, Glen Rock, NJ 07452, (201) 445-4532.

WANTED: CT-64 or similar ASCII terminal with or without monitor, graphics option preferred. Disk drives, printer, and other peripherals compatible with SwTPC 6800 system. Greg Ham, 4048 Southwest 8th St., Plantation, FL 33317, (305) 792-4204.

FOR SALE: OSI Superboard and 610 board in a homemade case. 16K of memory, video display, cassette recorder, many programs, and complete documentation. System: $650, computer only: $600. Don Bolton, 703 South 1st St., Selah, WA 98942, (509) 697-4471.

FOR SALE: Complete your collection. Back issues of BYTE in very good condition: June 1977; May to December 1978; January to December 1979 (except April). I would prefer selling the entire group fo $30 (including postage) but will sell individual issues for $2 or best offers. Please note: I will wait two weeks for check to clear before mailing. L. B. Judy, 1374 East Chandler Ave., Evansville, IN 47714.

WILL SWAP: SOL-20 user interested in swapping computer game programs (32K or less) and hardware ideas. If interested, send me a letter! Ray White, 600 Santa Monica Rd., London, Ontario, N6H 3W1 Canada.

FOR SALE: Intel Multibus computer SBC-80/10, 32K bytes of dynamic RAM consisting of two SBC-016 boards. All boards look new, work, and come with manual. $375 or best offer. Gordon Ting, 605 Leland Ave. #403, St. Louis, MO 63130, (314) 727-4138.

FOR SALE: IMSAI RAM III 64K dynamic RAM with 48K: $200. SSM VB1C video controller: $150. SSM MB8A 16K EPROM board with 14K BASIC: $100. SSM CB1A 8080 processor board, $100; with keyboard and case: $50. A complete system for only $500. Includes all documentation, manuals, etc. I will pay postage and insurance. David Potts, 13395 Madison Ave. #101, Lakewood, OH 44107, (216) 266-6886 between 8 and 5.

FOR SALE: Disk drives for the Apple II. I have a Micro-Sci A-2 with control card, a Micro-Sci A-40, and an A-70 with one control card. All still under warranty. Will sell all or part. A-40 or A-2 for $350 ($420 with control card). A-70 for $460 ($535 with control card). F. Markwell, 409 Lacy, Las Vegas, NV 89107, (702) 870-9908 after 4 p.m. PT.

FOR SALE: Mountain Computer A/D + D/A. Has 16 fast input and output analog channels with 8-bit resolution. I/O cables, manual, and demonstration disk are included: $250. Scott Merritt, 719 Lyons Ave., Charlottesville, VA 22901, (804) 293-8024.

FOR SALE: S-100 boards. Versafloppy I floppy-disk controller; $175. Altair 680 6800 computer with processor board and mainframe enclosure; $250. Altair 16K static RAM board; $125. Morrow Designs Speakeasy cassette interface; $125. Two Siemens FD-108 (Shugart SA800 equivalents), new; $350 each or $675 for both disk drives; Four Ithaca IA-2 8080A processor boards, unused; $125 each. First certified check or money order takes item(s). If sold already, check will be returned. I pay shipping. Enclose SASE to return check in case you're too late. Dana Jackson, 14613 East Kettleman Lane, Lodi, CA 95240.

FOR SALE: HP-41C card reader (82104A) and 60 cards plus two holders. Tested but unused. $120 or best offer. Charles Wolf, 333 Hyde #7, San Francisco, CA 94109, (415) 928-0421.

WANTED: Data manual for General Instruments AY-3-8900 Standard Television Interface Chip (STIC). Data manual is no longer available from vendor. Ralph Johnson, 1837 Aglen St., Roseville, MN 55113, (612) 487-2154.

WANTED: Used DEC VT-100 monitor. I have a VT-100 keyboard and need something compatible with it. If not available, I will swap you a keyboard plus cash for a used terminal from any reputable manufacturer. Louis Yelgin, 18 Oxford St., Malden, MA 02148, (617) 322-3011.

BOMB

BYTE's Ongoing Monitor Box

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Programming Woes Speak to Many

James L. Woodward was evidently speaking to many readers in his article "What Makes Business Programming Hard?" in which he described the problems of writing software to handle routine business tasks. Mr. Woodward placed first in the October BOMB contest for his theme-related article. He will receive the $100 prize. Second place and its $50 kitty goes to Jerry Pournelle for "A BASIC and Pascal Benchmark, Elegance, Apologies, and FORTH." Although the first part of his article brought Steve Ciarcia first place in September's BOMB, "Build the Microvox Text-to-Speech Synthesizer, Part 2: Software" placed third in the October contest.

Reader Service

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JANUARY 1983
4113

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BYTE'S BOMB is your direct line to the editor's desk. Each month, the authors of the two top-rated articles receive bonuses based on your evaluation. First look at the list of this month's articles and corresponding article numbers (located in the unclassified ads section on the page preceding the Reader Service list), then rate each article you've read as **Excellent, Good, Fair,** or **Poor**, based on your overall impression of the article, by circling the appropriate number in each column below. Your feedback helps to produce the best possible magazine each month.

Article No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Excellent	801	805	809	813	817	821	825	829	833	837	841	845	849	853	857	861	865	869	873	877	881	885	889	893	897
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Comments ______________________

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4 24 44 64 84	104 124 144 164 184	204 224 244 264 284	304 324 344 364 384	404 424 444 464 484	504 524 544 564 584	604 624 644 664 684
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9 29 49 69 89	109 129 149 169 189	209 229 249 269 289	309 329 349 369 389	409 429 449 469 489	509 529 549 569 589	609 629 649 669 689
10 30 50 70 90	110 130 150 170 190	210 230 250 270 290	310 330 350 370 390	410 430 450 470 490	510 530 550 570 590	610 630 650 670 690
11 31 51 71 91	111 131 151 171 191	211 231 251 271 291	311 331 351 371 391	411 431 451 471 491	511 531 551 571 591	611 631 651 671 691
12 32 52 72 92	112 132 152 172 192	212 232 252 272 292	312 332 352 372 392	412 432 452 472 492	512 532 552 572 592	612 632 652 672 692
13 33 53 73 93	113 133 153 173 193	213 233 253 273 293	313 333 353 373 393	413 433 453 473 493	513 533 553 573 593	613 633 653 673 693
14 34 54 74 94	114 134 154 174 194	214 234 254 274 294	314 334 354 374 394	414 434 454 474 494	514 534 554 574 594	614 634 654 674 694
15 35 55 75 95	115 135 155 175 195	215 235 255 275 295	315 335 355 375 395	415 435 455 475 495	515 535 555 575 595	615 635 655 675 695
16 36 56 76 96	116 136 156 176 196	216 236 256 276 296	316 336 356 376 396	416 436 456 476 496	516 536 556 576 596	616 636 656 676 696
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